BULLETIN 350

BRACHIOPODS *[SCHIZOPHORIA, STROPHODONTA (STROPHODONTA), NERVOSTROPHIA, EOSTROPHALOSIA* AND *DEVONOPRODUCTUS]* FROM THE LOWER UPPER DEVONIAN WATERWAYS FORMATION OF NORTHEASTERN ALBERTA

A.W. NORRIS

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PREFACE

This report presents the results of a detailed and systematic study of a part of the rich brachiopod fauna of the lower Upper Devonian Waterways Formation of northeastern Alberta. The exposed sequence of Waterways beds of the Athabasca-Clearwater rivers area is of special interest because it contains what is probably the richest brachiopod fauna of this age so far encountered in northwestern Canada. Supplementary data on the Waterways faunas of two other areas, including the brachiopods, were provided by two recently completed reports by A.W. Norris and T.T. Uyeno covering the Gypsum Cliffs area on Peace River and the Birch River area, both in northeastern Alberta. The study of other groups of Waterways brachiopods from the Athabasca-Clearwater rivers outcrop belt is continuing and results will be presented in succeeding reports.

To meet the need for precise paleontological information on the fossils and distribution, considerable time and effort were devoted to positioning the samples from isolated outcrops as accurately as possible within the composite stratigraphic sequence. For national and international correlations the brachiopod zones and faunas are collated with the conodont zonal scheme previously established by T.T. Uyeno for the Waterways Formation. Such correlations are important in the ultimate selection of a Middle-Upper Devonian boundary and the ongoing search for fossil fuels and minerals.

Ottawa
April 1981

W.W. Hutchison
Director General
Geological Survey of Canada

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BRACHIOPODS (*SCHIZOPHORIA*, *STROPHODONTA (STROPHODONTA)*, *NERVOSTROPHIA*, *EOSTROPHALOSIA* AND *DEVONOPRODUCTUS*) FROM THE LOWER UPPER DEVONIAN WATERWAYS FORMATION OF NORTHEASTERN ALBERTA

Abstract

This is the third in a series of reports providing results of a systematic study in progress of the rich and diverse brachiopod fauna of the Waterways Formation outcropping in the Athabasca-Clearwater rivers area of northeastern Alberta. Four of the five members of the formation comprising the Firebag, Calumet, Christina, and Moberly are well represented in outcrops; the uppermost Mildred Member is present only in the subsurface.

Sixteen brachiopod species of four genera and one subgenus from the outcrop succession are described and illustrated. These comprise: the genus *Schizophoria* – four species, one of which is new; the subgenus *Strophodonta (Strophodonta)* – seven species, five of which are new; the genus *Nervostrophia* – one indeterminate species; the genus *Eostrophalosia* – one species; and the genus *Devonoproductus* – three species, one of which is new.

The new taxa comprise: *Schizophoria warreni* n. sp., *Strophodonta (Strophodonta) albertensis* n. sp., *S. (S.) calumetensis* n. sp., *S. (S.) clearwaterensis* n. sp., *S. (S.) engstromi* n. sp., *S. (S.) moberliensis* n. sp., and *Devonoproductus reticulocostus* n. sp.

The zonal marker, *Stropheodonta costata* of previous authors for the Calumet Member, is here replaced by *Strophodonta (Strophondonta) clearwaterensis* as a more appropriate term.

The stratigraphic range of the described brachiopods collated with the standard conodont zonal scheme for North America is from the Upper *dengleri* Subzone through the Lower *asymmetricus* Zone into the lower part of the Middle *asymmetricus* Zone of the lower Frasnian of the lower Upper Devonian.

Résumé

Le présent rapport est le troisième d'une série de comptes rendus de l'étude systématique qu'on mène actuellement sur la faune riche et diversifiée que constituent les brachiopodes fossilisés de la formation de Waterways; cette formation affleure dans le région délimitée par les rivières Athabasca et Clearwater dans le nord-est de l'Alberta. Sur les cinq niveaux de la formation, ceux de Firebag, Calumet, Christina et Moberly, sont bien représentés dans l'affleurement, mais le niveau supérieur, celui de Mildred, n'est présent que dans la couche sous-jacente.

On donne la description et l'illustration de 16 espèces de brachiopodes découverts dans la succession de l'affleurement. Ces espèes se regroupent en 4 genres et 1 sous-genre: il s'agit des genres *Schizophoria*, qui comprend 4 espèces dont une nouvelle, *Nervostrophia*, qui comprend une espèce indéterminée, *Eostrophalosia* qui comprend une espèce, *Devonoproductus* qui comprend 3 espèces dont une nouvelle et du sous-genre *Strophodonta (Strophodonta)* qui comprend 7 espèces dont 5 nouvelles.

Les nouveaux taxons sont: *Schizophoria warreni* n. sp., *Strophodonta (Strophodonta) albertensis* n. sp., *S. (S.) calumetensis* n. sp., *S. (S.) moberliensis* n. sp., et *Devonoproductus reticulocostus* n. sp.

Le marqueur zonal *Stropheodonta costata* utilisé pour le niveau de Calumet, a été rebaptisé *Strophodonta (Strophodonta) clearwaterensis*, appellation jugée plus appropriée.

Par comparison au schéma zonal standard des conodontes en Amérique du Nord, l'échelle stratigraphique des brachiopodes décrits dans le rapport s'étend de la sous-zone *dengleri* supérieure, en passant par la zone *asymmetricus* inférieure, jusque dans la partie inférieure de la zone *asymmetricus* moyenne du Frasnien inférieur, du début du Dévonien supérieur.

INTRODUCTION

Location

The brachiopods described in this report are from beds of the Waterways Formation outcropping along the Clearwater and Athabasca rivers and some tributary streams in northeastern Alberta (Fig. 1). Beds of the Waterways Formation are discontinuously exposed along the Clearwater River from the vicinity of Cascade Rapids (ca. 56°42'25"N, 110°18'40"W) to the junction with Athabasca River at Fort McMurray (56°45'00"N, 111°22'50"W) over a river distance of about 82 km. Along Athabasca River, outcrops extend from just above Crooked Rapids (56°39'50"N, 111°48'00"W), a 42 km river distance above Fort McMurray, to a point a few kilometres below Fort MacKay (57°12'30"N, 111°41'00"W), about a 55.4 km river distance below Fort McMurray. Two other isolated outcrops of the Waterways Formation occur below this point on the Athabasca River, one on the west bank of the river just below the mouth of Pierre River (ca. 57°27'03"N, 111°37'56"W), and the other on the east bank of the river (ca. 57°30'26"N, 111°32'50"W), about 2.2 km below the mouth of Eymundson Creek. On the Department of Public Works (1952) navigation charts covering the route between Waterways and Fort Smith, the mouth of the Clearwater River, Fort McKay, and the latter two Waterways outcrops are near mileages 4, 38, 58 and 60, respectively, with mileages scaled from the Upper Government Wing Dam located at Waterways on the Clearwater River.

Fort McMurray is connected with centres in the south by an all weather hard surfaced road, scheduled air flights and a rail line.

Previous brachiopod investigations

In the following review of previous brachiopod investigations only those representatives of fossil groups studied in this report are mentioned; associated fossils, where present, are omitted for the sake of brevity. In addition, this review concentrates mainly on those references that include illustrations of relevant fossils.

Meek (1868) in his study of fossils from the Mackenzie River drainage area included descriptions and illustrations of one schizophoriid, two strophodontids and one productellid, amongst other forms, from Devonian beds (Waterways Formation) outcropping along the Clearwater River. These fossils were referred to as "*Orthis lowensis* Hall" (Meek, 1868, p. 90, 91, Pl. 12, figs. 2a - 2h), "*Strophomena* (*Strophodonta*) *demissa* Conrad" (Meek, 1868, p. 87, 88, Pl. 13, figs. 6a - 6c), "*Strophomena* (*Strophodonta*) *subdemissa* Hall" (Meek, 1868, p. 88, Pl. 13, figs. 7a - 7c), and "*Productus dissimilis* Hall?" (Meek, 1868, p. 91, Pl. 13, figs. 3a - 3c).

Whiteaves (1891) in his study of "The Fossils of the Devonian Rocks of the Mackenzie River Basin" listed fossils from beds now referred to as the Waterways Formation from a number of localities along the Clearwater and Athabasca rivers. From beds now assigned to the Firebag Member located on Athabasca River 48.3 km below Red River (=MacKay River), Whiteaves (1891, p. 248) listed "*Productella dissimilis*", "*Orthis striatula*", and "*Strophodonta demissa*" , amongst other fossils. From beds now assigned to the Calumet Member located on Athabasca River 4.8 km below the Calumet River or 29 km below Red River (=MacKay River), Whiteaves (1891, p. 248) listed "*Productella dissimilis*", "*Orthis striatula*", and "*Strophodonta demissa*, Conrad", amongst other forms. From beds now assigned to the Moberly Member, Whiteaves (1891, p. 247 - 8) listed fossils from three localities comprising: (1) on Clearwater River about 6 km below the Pembina (=Christina) River; (2) on Athabasca River within the first 16 km below the mouth of Clearwater River; and (3) on Athabasca River opposite La Saline and about 40.2 km below the mouth of Clearwater River. Fossils from locality (1) included: "*Orthis striatula*, Schlotheim"; from (2): "*Strophalosia productoides* Nicholson"; and from (3): "*Strophalosia productoides*" and "*Productella dissimilis*, Hall".

Warren (1944) in his paper, "Index Brachiopods of the Mackenzie River Devonian", described and illustrated three species of *Schizophoria* from the Waterways Formation of northeastern Alberta, comprising *Schizophoria lata* Stainbrook, *Schizophoria allani* and *Schizophoria athabaskaensis*, the latter two being new species. Warren (1944, p. 109) mentioned also the presence of *Schizophoria lowensis* (Hall) in the Waterways Formation and pointed out that it was not a clear-cut form because it was difficult to distinguish full-grown forms of *S. lowensis* from young forms of *S. athabaskaensis*.

Bassett (1952MS, p. 129 - 130, Pl. 1, figs. 15 - 18) in his study entitled "Correlations of Devonian sections in northern Alberta and Northwest Territories" described and illustrated a specimen of *Schizophoria athabaskaensis* Warren collected from the north bank of Clearwater River about 19 km above the mouth of Christina River. This locality would place it within the Calumet Member of the Waterways Formation.

Warren and Stelck (1956) in their illustrations of Devonian faunas of western Canada included a number of brachiopods from the Waterways Formation. As part of their "Allanaria" *allani* fauna Warren and Stelck (1956, Pls. 11,12) illustrated *Schizophoria allani* Warren, *Schizophoria lata* Stainbrook, *Schizophoria athabaskaensis* Warren, *Productella* cf. *hebertelli* Stainbrook, and *Strophodonta subdemissa* Hall. The source beds of the "Allanaria" *allani* fauna were indicated as the Waterways Formation at and near Fort McMurray. Included in their succeeding *Eleutherokomma humiltoni* fauna, Warren and Stelck (1956, Pl. 13) illustrated *Strophodonta plicata* Hall, *Strophodonta lowensis* Owen, *Strophodonta* cf. *umbonata* Stainbrook, *Strophodonta halli* Cleland, *Strophodonta* cf. *dorsata* Stainbrook, and *Productella* sp. They indicated that the source beds of this latter fauna were from the upper part of the Waterways Formation, Athabasca River, Alberta.

Crickmay (1963) described and illustrated a number of new productellid brachiopods from western Canada in which he included three forms from the Waterways Formation and equivalent beds of northern Alberta. These comprise *Eostrophalosia peddari* Crickmay, *Chonopectoides catamorphus* Crickmay, and *Devonoproductus tertius* Crickmay.

Norris (Norris and Uyeno, in press) in a study that included the brachiopods of the Peace Point Member of the Waterways Formation outcropping at Gypsum Cliffs on Peace River in northeastern Alberta described and illustrated the following amongst other forms: *Schizophoria lata* Stainbrook, *Schizophoria* sp. cf. *S. allani* Warren, and *Strophodonta* sp. The Peace Point Member at Gypsum Cliffs is equivalent to the lowermost part of the Firebag Member of the Waterways Formation in the Athabasca-Clearwater rivers area of northeastern Alberta.

Norris (Norris and Uyeno, 1981) in a study that included the brachiopod faunas of the Waterways Formation exposed along the upper reaches of Birch River in northeastern Alberta described and illustrated the following amongst other forms: *Schizophoria* sp. cf. *S. lata* Stainbrook, *Strophodonta* (*Strophodonta*) sp. A, *Nervostrophia* sp., and *Devonoproductus* sp. cf. *D. tertius* Crickmay. The beds of the Waterways Formation exposed on Birch River are equivalent to the upper part of the Calumet and lower part of the Christina members.

Numerous other investigators including early explorers, naturalists, government, university and industry geologists have presented faunal lists of brachiopods from the Waterways Formation that included schizophoriids, strophodontids, nervostrophiids and productellids in their discussions of the Waterways rocks and faunas and correlations with other areas. These include: Franklin (1828), Richardson (1851), Isbister (1855), Bell (1884), McConnell (1893), Allan (1921, 1943), Warren (1933), MacDonald (1947, 1955), Warren and Stelck (1950), Crickmay (1950, 1953, 1957, 1966), McLaren (1954), Taylor (1957), Belyea and McLaren (1957), Carrigy (1959), Norris (1963, 1973), Raasch in Dooge (1966) and in Maurin and Raasch (1972), and others. The more useful of the above reports that provide data on the localities, distribution and ranges of the various brachiopods in the Waterways Formation include those by Allan (1943), MacDonald (1947), Crickmay (1957, 1966), Carrigy (1959), and Norris (1963).

Present work

The results presented in this report are part of a current detailed study of the brachiopods of the lower Upper Devonian Waterways Formation of northeastern Alberta. Because of the numerical abundance and diversity of this fauna it was decided to present the results of the study in easily manageable parts. The present work covers the following genera and subgenera: *Schizophoria*, *Strophodonta* (*Strophodonta*), *Nervostrophia*, *Eostrophalosia* and *Devonoproductus*. It is based on collections made by the writer in 1956, 1961, 1973 and 1979, and older Geological Survey of Canada collections from the Athabasca-Clearwater rivers area of northeastern Alberta. Supplementary data on the Waterways brachiopods and rocks were provided by

recently completed studies by Norris and Uyeno (1981; in press) covering the Gypsum Cliffs and Birch River areas, respectively.

The present study is based on the examination of 643 samples from 247 scattered measured outcrop sections of the Waterways Formation along the Clearwater and Athabasca rivers and tributary streams. To position the samples as accurately as possible in the composite stratigraphic sequence, all of the outcrop sections as well as twelve subsurface well sections were plotted in sequence to a common scale. A variety of methods were used in correlating between sections including use of local and regional dips, tracing key marker beds such as unit 37 of the Moberly Member (Norris, 1963, p. 105) along the Athabasca River, and comparison with the lithology and fossils in the nearest subsurface sections.

To simplify the presentation of data in this study, only those outcrop sections from which brachiopods have been illustrated are shown schematically in Figure 2. The thicknesses of the members of the Waterways Formation shown in Figure 2 are those in the type Bear Biltmore No. 1 well (7-11-87-17-W4), although it is known that the thicknesses of these members vary slightly within the outcrop belt. The locations of the selected sections as well as the distribution of the Waterways Formation and its members in the study area are shown in Figure 1.

The taxonomic arrangement of the Waterways brachiopods proposed in this report is based on a qualitative laboratory examination for delimitation of species. This is based on the belief that the eye remains the best tool for detecting subtle differences in shape and ornamentation. Some of the Waterways brachiopods treated in this report display considerable infraspecific variation. For this reason a number of specimens are illustrated for each species in an attempt to show various growth stages and some of the range of variation in gross shape. For each of the illustrated specimens, linear dimensions and rib counts are presented, along with other data, as an aid to visualizing gross shape and variations in costellate or costate ornamentation.

Comparison of Waterways forms with other Canadian material has been aided by the presence in GSC collections of types, topotypic material and plaster and rubber replicas. For comparison of material outside Canada the task is more difficult because the writer has relied mainly on illustrations and descriptions in the literature.

Acknowledgments

Able assistance in the field was provided by D. B. McKennitt in 1956, P. A. Bolton in 1961, S. Carbone in 1973, and R. Schulz in 1979. The brachiopods of this report were photographed by B. C. Rutley and W. B. Sharman of the Photography Section of the Geological Survey of Canada in Calgary. Critical comments by G. O. Raasch and T. T. Uyeno contributed to improvements in the presentation of results of this report.

STRATIGRAPHY

Waterways Formation

The geology of the Waterways Formation in the Athabasca-Clearwater rivers area has been described in varying detail by a number of workers including Cricklmay (1957), Carrigy (1959), Norris (1963, 1973), Uyeno (1967, 1974), Norris and Uyeno (1981, in press), and others. For this reason only a brief résumé will be presented here to provide a framework for the biostratigraphy of the brachiopods described and illustrated in this report. This summary closely follows data presented in Norris (1973, p. 31 - 37).

The name Waterways Formation was introduced by Warren (1933, p. 149) to apply to that part of the Devonian succession overlying an evaporitic sequence in the lower Athabasca River area. He indicated a thickness of 123.4 m for the formation based on a log of the Alberta Government Salt Well No. 1 drilled at Fort McMurray and pointed out that the upper boundary was an erosional surface. Wells subsequently drilled west of Fort McMurray indicated younger Devonian strata unconformably underlying the Lower Cretaceous McMurray Formation (the "Athabasca Tar Sands"). About 91 m of these younger Devonian strata are included in the Waterways Formation based on close lithological and faunal similarities (Cricklmay 1957; Norris, 1963, p. 25). Cricklmay (1957) subdivided the Waterways Formation into five members using the Bear Biltmore No. 1 well (7-11-87-17-W4) located about 77 km west-southwest of Fort McMurray as his standard for comparison with the incomplete succession on the Clearwater and Athabasca rivers. The complete Waterways Formation may be defined as the sequence of shale and argillaceous limestone alternating with mainly limestone units lying between the top of the Devonian Slave Point Formation and the base of the Devonian Cooking Lake Formation of the Woodbend Group (Norris, 1963, p. 25). The complete thickness of the Waterways Formation in the Bear Biltmore No. 1 well is 213.8 m lying between depths of 299 to 512.8 m. The lower contact is probably unconformable with the Slave Point Formation and the upper contact with the Cooking Lake Formation appears to be transitional.

The five members of the Waterways Formation erected by Cricklmay (1957) are as follows in ascending sequence (see Table of Upper Devonian through Lower Cretaceous formations): Firebag, Calmut (changed to Calumet by Carrigy, 1959; Norris, 1963), Christina, Moberly and Mildred. Detailed descriptions of these members including outcrop and subsurface sections are provided by Carrigy (1959) and Norris (1963), and more recent summaries have been presented by Norris (1973) and Uyeno (1974).

Firebag Member

The basal Firebag Member of the Waterways Formation consists mainly of olive green calcareous shale, olive green limestone, argillaceous limestone, and noncalcareous shale. A thin fragmental limestone commonly is present at the base. Exposures of the Firebag Member are present in a belt about 18 km wide along Clearwater River between a point near Cascade Rapids to about 8 km above the mouth of Cottonwood Creek (Fig. 1). Within this belt good exposures are known also along the lower stretches of Edwin Creek and High Hill River. To the north, along the lower Athabasca River, two closely spaced outcrops are known on the east bank of the river about 103 km downstream from the Waterways wharf. A single exposure of the member occurs also on Firebag River (Norris, 1973, fig. 4), after which the member was named. The thickness of the Firebag Member is 52 m in the type Bear Biltmore No. 1 well. Other wells in the report area show that the member decreases slightly in thickness from east to west and from north to south (Norris, 1963, p. 27). The Firebag Member traced southward in the subsurface is approximately equivalent to the Bh. 2 unit of Belyea (1957) of the Beaverhill (Lake) Formation. The latter unit has since been raised to group status by Leavitt and Fischbuch (1968).

The relevant faunas of the members of the Waterways Formation are discussed in a succeeding part of this report.

Calumet (Calmet) Member

The Calumet Member (Crickmay, 1957) in its type section comprises 31 m of fine-grained and clastic limestone lying between the Firebag Member (below) and Christina Member (above). It consists mainly of grey to buff clastic limestone, variably argillaceous limestone, some olive green nodular calcareous shale, and minor noncalcareous shale. Both the lower and upper contacts of the member are marked by a change from limestone to shale in most of the wells in the report area. The outcrop belt of the Calumet Member along Clearwater River is about 20 km wide measured perpendicular to strike. Within this belt about eight scattered outcrops of the member are present along Clearwater River extending from about 7 km above Cottonwood Creek to about 3 km above the mouth of Christina River. To the north, only one outcrop of the Calumet Member is known on the Athabasca River, and it is located on the west bank of the river immediately below the mouth of Pierre River, about 93 km downstream from the Waterways wharf. The thickness of the Calumet Member in the subsurface of the report area varies from a minimum of 27 m to a maximum of 31 m. The Calumet Member correlates approximately with the Bh. 3 unit of Belyea (1957) of the Beaverhill (Lake) Formation (Group) to the south.

Christina Member

The Christina Member, defined by Crickmay (1957, p. 9), lies between the Calumet Member (below) and Moberly Member (above). It consists mainly of greenish grey shale, grey argillaceous limestone, pale brown aphanitic limestone, and minor pale brown fragmental limestone. Sandstone and sandy limestone beds occur locally in the upper part of the member in some exposures on Christina River. Outcrops showing thin sequences of parts of the Christina Member are present between 2.4 and 4.8 km up the Christina River. The lower parts of some of the outcrop sections in the vicinity of Fort MacKay on Athabasca River and on Muskeg River may also be assigned to this member. The thickness of the Christina Member varies from a minimum of 23 m to a maximum of 37 m in the subsurface of the report area (Norris, 1963, p. 30). In the subsurface to the south the Christina Member is correlated approximately with the Bh. 4 unit of Belyea (1957) of the Beaverhill (Lake) Formation (Group).

Table of Upper Devonian through Lower Cretaceous formations in the Athabasca-Clearwater rivers area, northeastern Alberta

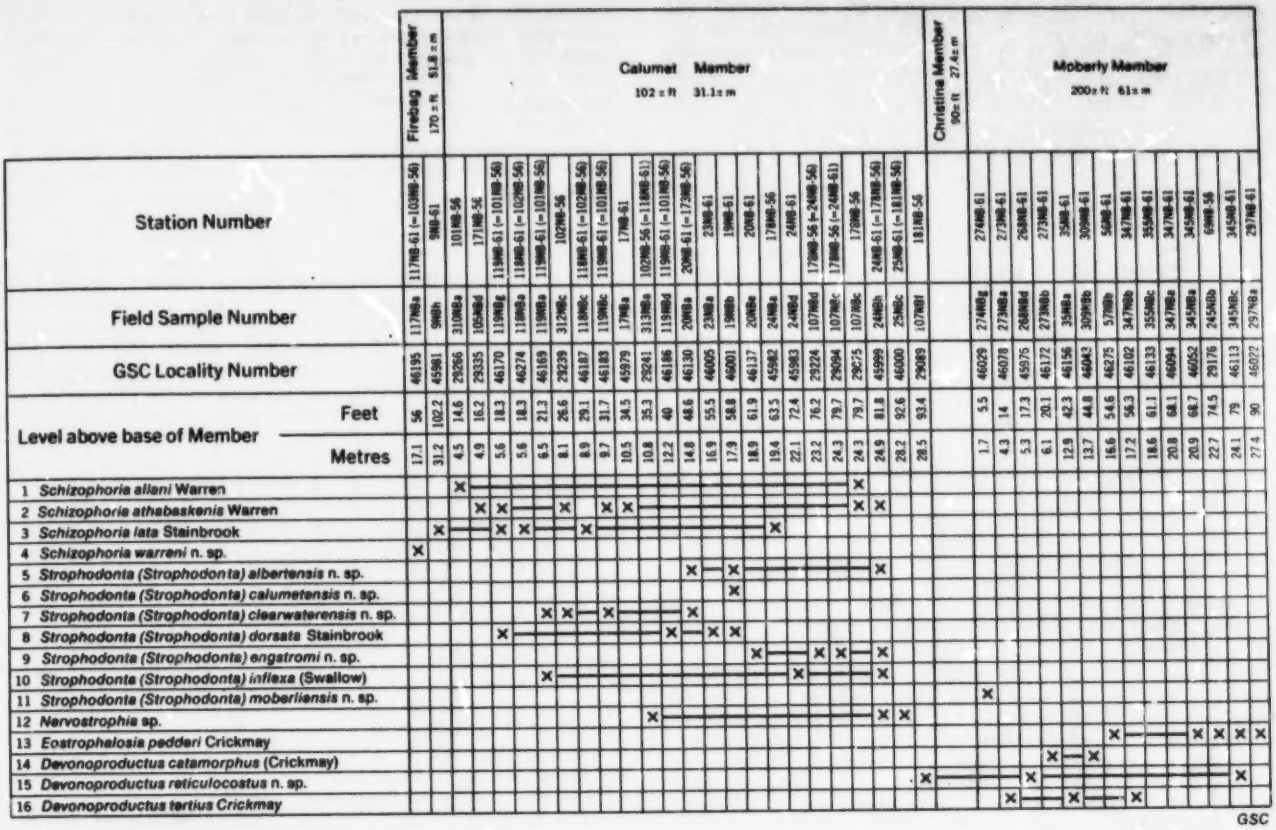
System or Series	Formation and Thickness	Member and Thickness	Lithology
LOWER CRETACEOUS	McMurray		
	Erosional unconformity		
UPPER DEVONIAN *	Waterways 702± ft[1] (214± m)	Mildred[2] 140± ft[1] (46.7 ± m)	Argillaceous limestone and shale
		Moberly 200± ft[1] (61 ± m)	Clastic limestone, argillaceous limestone, and some shale
		Christina 90± ft[1] (27.4 ± m)	Argillaceous limestone, limestone, shale, and some sandy limestone and sandstone
		Calumet 102± ft[1] (31.1 ± m)	Resistant fine-grained and clastic limestone, argillaceous limestone, and some shale
		Firebag 170± ft[1] (51.8± m)	Shale and argillaceous limestone
	?Unconformity		
	Slave Point 5.5 - ?13 ft[1] (1.7 - ?4 m)		Limestone, some dolomite, in places brecciated and associated with shale

[1] Thickness in subsurface. [2] Not exposed

(Modified after Norris, 1963, p. 7)

* At a meeting of the Subcommission on Devonian Stratigraphy held in Frankfurt on Main, West Germany, in 1982, a majority vote selected the base of the conodont Lower *asymmetricus* Zone to mark the base of the Upper Devonian internationally. On the basis of this decision the Middle-Upper boundary in the study area would now be placed within the Calumet Member of the Waterways Formation.

Figure 3. *Distribution chart, Waterways Formation.*


Firebag Member 170 ± ft 51.8 ± m
Calumet Member 102 ± ft 31.1 ± m
Christina Member 90± ft 27.4± m
Moberly Member 200± ft 61± m
Station Number
Field Sample Number
GSC Locality Number
Level above base of Member
Feet
Metres
1 Schizophoria allani Warren
2 Schizophoria athabaskensis Warren
3 Schizophoria lata Stainbrook
4 Schizophoria warreni n. sp.
5 Strophodonta (Strophodonta) albertensis n. sp.
6 Strophodonta (Strophodonta) calumetensis n. sp.
7 Strophodonta (Strophodonta) clearwaterensis n. sp.
8 Strophodonta (Strophodonta) dorsata Stainbrook
9 Strophodonta (Strophodonta) engstromi n. sp.
10 Strophodonta (Strophodonta) inflexa (Swallow)
11 Strophodonta (Strophodonta) moberliensis n. sp.
12 Nervostrophia sp.
13 Eostrophalosia pedderi Crickmay
14 Devonoproductus catamorphus (Crickmay)
15 Devonoproductus reticulocostus n. sp.
16 Devonoproductus tertius Crickmay
GSC

Moberly Member

The Moberly Member, defined by Crickmay (1957, p. 8), overlies the Christina Member, and where it is complete in the subsurface, it is overlain by the Mildred Member. Throughout the crop belt the top of the member is an erosional surface where it is unconformably overlain by beds of the Lower Cretaceous McMurray Formation with progressively younger beds being overlapped from east to west. The Moberly Member consists mainly of an alternating sucession of light olive green, rubbly, thinly interbedded, variably argillaceous limestone and shale, and even hard beds of pale brown, aphanitic, fragmental limestone. Shale content in the member appears to increase considerably from south to north, especially in the lower and upper parts of the member. Outcrops of the Moberly Member occur at seven main localities along the Clearwater River from 9.6 to 21 km (straight line distance) upstream from the mouth of the river. Along the Athabasca River exposures of this member extend from just above Crooked Rapids, 38.6 km above the junction with Clearwater River, to 54.7 km below the junction, or just below the Fort McKay Settlement. Outcrops of this member are also present along the lower stretches of some of the tributary streams emptying into the Athabasca River, particularly along the MacKay, Beaver and Muskeg rivers. The thickness of the Moberly Member is 61 m in the type Bear Biltmore No. 1 well where it is complete. The Moberly Member to the south in the subsurface is correlated approximately with Belyea's (1957) unit Bh. 5 of the Beaverhill (Lake) Formation (Group).

Mildred Member

The Mildred Member, named by Crickmay (1957, p. 8), is the uppermost unit of the Waterways Formation. In the type Bear Biltmore No. 1 well, it occurs between depths of 299 and 341.4 m. It conformably overlies the Moberly Member of the Waterways Formation and conformably underlies the Cooking Lake Formation of the Woodbend Group. In the type Bear Biltmore No. 1 well, where it is 42.7 m thick, the member consists of greenish grey calcareous shale, greenish grey argillaceous limestone, and some pale brown aphanitic, clastic limestone. So far as known there are no outcrops of this member in the Athbasca-Clearwater rivers area. In the Bear Vampire No. 1 well (7-28-87-12-W4) located near the western edge of the Waterways outcrop belt, about 32 km west-southwest of Fort McMurray, the highest Paleozoic beds penetrated are part of the Moberly Member. To the south in the subsurface the Mildred Member correlates approximately with Belyea's (1957) unit Bh. 6 of the Beaverhill (Lake) Formation (Group).

BIOSTRATIGRAPHY

Brachiopod and conodont zones in the Waterways Formation

Some of the earlier attempts at zoning the Upper Devonian rocks of western Canada on the basis of brachiopods incorporated information on the succession of faunas in the Waterways Formation of northeastern Alberta. These include the zonal schemes of Warren and Stelck (1950, 1956), McLaren (1954), Crickmay (1957, 1966, 1967) and others.

Three zones named by Warren and Stelck (1950) on faunas in the Waterways Formation are as follows in ascending sequence: the *Lingula* cf. *spatulata* Zone occurring in the lower 19 m of shale beds; the *"Spirifer" allani* Zone, about 91 m thick, occuring in the lower limestone part of the Waterways Formation; and the *Eleutherokomma hamiltoni* Zone occurring in what was thought to be the uppermost beds of the Waterways Formation exposed on the Athabasca River (see Fig. 4). In their zonal scheme the fossils listed by Warren and Stelck (1950, p. 71) for the *E. hamiltoni* Zone are largely those

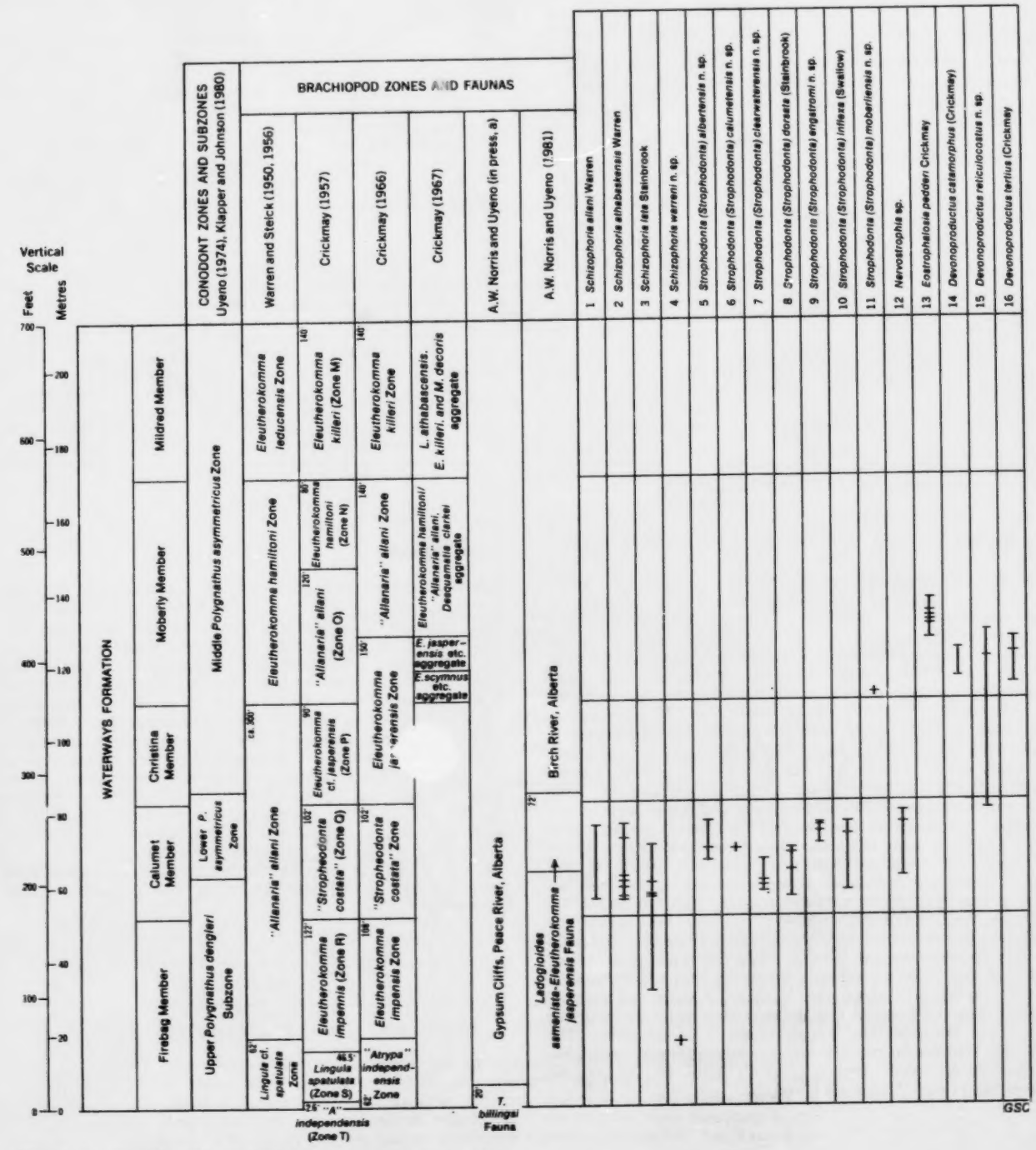


Figure 4. *Stratigraphic distribution, Waterways Formation.*

that occur in stratigraphically lower beds, now known as the Calumet Member of the Waterways Formation, rather than the beds now known as the Moberly Member. At that time it was commonly assumed that the Waterways beds now assigned to the Calumet Member outcropping on the lower Athabasca below Fort MacKay were stratigraphically higher than those in the vicinity of Fort MacKay. The fossils of these three zones in the Waterways Formation were later illustrated by Warren and Stelck (1956, Pls. 10 - 13).

Two of the Upper Devonian rhynchonellid zones recognized by McLaren (1954) in the Canadian Rocky Mountains were noted in the Waterways Formation comprising elements of the *"Pugnoides" kakwaensis* and *"Nudirostra"* zones. The rhynchonellids in the basal Waterways Formation were later described by McLaren (1962) as *Ladogioides pax* and *"Leiorhynchus" russelli* of the *Ladogioides kakwaensis* Zone. Recent evidence presented by Raasch (in Maurin and Raasch, 1972 Pl. 3) suggests that *Ladogioides kakwaensis* McLaren of the Rocky Mountains occurs at a higher stratigraphic level than *Ladogioides pax* McLaren in the Waterways Formation. The two species have never been found in sequence in the same section. The *athabascensis* Zone [*Calvinaria variabilis athabascensis* (Kindle) of McLaren (1962, p. 39 - 43, 115)] was noted by McLaren (1954, p. 170) in the Bear Beaumont No. 1 well (14-25-77-18-W4) between 553.8 and 560.2 m depths, an interval which Belyea (1952, fig. 3) correlated with the upper Beaverhill (Lake) Formation in the Bear Biltmore No. 1 well (7-11-87-17-W4). In current stratigraphic terminology this interval is near the top of the Mildred Member of the Waterways Formation.

Crickmay (1957, p. 11) recognized eight brachiopod zones within the Waterways Formation based on the succession of faunas in the Athabasca-Clearwater rivers area with thicknesses given for each zone represented in the Bear Biltmore No. 1 well (7-11-87-17-W4). In the Firebag Member he recognized, in ascending sequence, zones characterized by the following: *"Atrypa" independensis* (Zone T), 0.8 m thick; *Lingula spatulata* (Zone S), 14.2 m thick; and *Eleutherokomma impennis* (Zone R), 37.2 m thick. He indicated that the Calumet Member was characterized by abundant *"Stropheodonta costata"* and other unique brachiopods (Zone Q), 31 m thick. The Christina Member was marked by the presence of *Eleutherokomma* cf. jasperensis and a small form of *"Allanaria"* (Zone P), 27.4 m thick. In the Moberly Member he recognized a lower *"Allanaria" allani* (Zone O), 36.6 m thick; and an upper *Eleutherokomma hamiltoni* (Zone N), 24.4 m thick. In the Mildred Member he recognized a fauna characterized by *Eleutherokomma killeri* (Zone M), 42.7 m thick.

Crickmay (1966, p. 17 - 20) in a slight modification of his earlier zonal scheme erected six brachiopod zones within the Waterways Formation of northeastern Alberta utilizing the succession in the Bear Biltmore No. 1 well (7-11-87-17-W4) which is the type section for the members of the formation. These are in ascending sequence: the upper part of the *"Atrypa" independensis* Zone in the lower 19 m of the Firebag Member; the *Eleutherokomma impennis* Zone in the upper 33 m of the Firebag Member; the *"Stropheodonta costata"* Zone in the 31 m of the Calumet Member; the *Eleutherokomma jasperensis* Zone in the 27.4 m of the Christina Member and in the lower 18.3 m of the overlying Moberly Member; the *"Allanaria" allani* Zone in the upper 42.7 m of the Moberly member; and *Eleutherokomma killeri* Zone in the 42.7 m of the Mildred Member of the Waterways Formation.

Three distinct faunas referred to as aggregates were later recognized by Crickmay (1967, p. 2) within the Moberly Member of the Waterways Formation and equivalent rocks although these were not tied in with any specific subsurface or outcrop section. These faunas comprise the following in ascending sequence: the *Eleutherokomma scymnus, Chonopectoides catamorphus* aggregate; the *Eleutherokomma jasperensis, Acutatheca (Minutilla) layeri - Acutatheca (Minutilla) minutilla, Emanuella sluzeri* aggregate; and the *Eleutherokomma hamiltoni/Allanella allani, Desquamatia clarkei* aggregate. Within the Mildred Member and equivalent rocks, Crickmay (1967, p. 2) listed the following as being a distinctive aggregate: *"Leiorhynchus athabascense"* Kindle, *Eleutherokomma killeri*, and *Minutilla decoris*.

Norris (Norris and Uyeno, in press) referred to the rich fauna in the Peace Point Member (about 6 m exposed) of the Waterways Formation at Gypsum Cliffs on Peace River in northeastern Alberta as the *Tecnocyrtina billingsi* Fauna after one of its more distinctive and widespread forms described and discussed by Johnson and Norris (1972). The presence of this form in the unnamed allochthonous beds at Powell Creek in the central Mackenzie River area of the District of Mackenzie had been formally recognized as the *Tecnocyrtina billingsi* Zone by Pedder (Lenz and Pedder, 1972 and Pedder, 1975). The Peace Point beds at Gypsum Cliffs are equivalent to the basal beds of the Firebag Member of the Waterways Formation in the Athabasca-Clearwater rivers area of northeastern Alberta.

The fauna in the Waterways beds (about 22 m exposed) on Birch River in northeastern Alberta was referred to as the *Ladogioides asmenista - Eleutherokomma jasperensis* Fauna by Norris (Norris and Uyeno, 1981). These beds are equivalent to parts of the Calumet and Christina Members of the Waterways Formation of the Athabasca- Clearwater rivers area.

Uyeno (in Klapper et al., 1971, p. 298, fig. 3, column 1; 1974) in his detailed study of the conodonts of the Waterways Formation both in outcrops and the subsurface has established the following succession. Conodonts indicative of the *Pandorinellina insita* Fauna occur in the Firebag Member and lower part of the Calumet Member; conodonts of the Lower *Polygnathus asymmetricus* Zone range throughout approximately the upper two-thirds of the Calumet Member into the lowermost part of the Christina Member; and conodonts characterizing the Middle *Polygnathus asymmetricus* Zone range throughout the upper Christina, and through the Moberly and Mildred members. The upper range of the Middle *Polygnathus asymmetricus* Zone in the Mildred Member of the Waterways Formation above the level studied by Uyeno was established by Pollock (1968).

In a recent revision of some of the conodont zones in North America, the conodonts marking the *Pandorinellina insita* Fauna of Uyeno (1974) in the Firebag Member were placed by Klapper and Johnson (1980, p. 415) in a newly created Upper *Polygnathus dengleri* Subzone. The base of the Upper *dengleri* Subzone was defined by Klapper and Johnson (1980, p. 415) on the first appearance of *Polygnathus norrisi* which in the Waterways Formation first appears at or very near the base of the Firebag Member.

Elements of the distinctive megafauna marking the base of the Firebag Member of the Waterways Formation and equivalent beds in western and northwestern Canada have been traditionally used to mark the base of the Upper Devonian throughout this area (Norris and Uyeno, in press). This level is slightly higher than that favoured by a majority of the members of the Subcommission on Devonian Stratigraphy at a meeting held in Spain, 1979. For international correlation they favoured the entry of the conodont *Polygnathus dispariis*, or slightly lower (undecided) level, as the eventual base of the Upper Devonian. The entry of this form marks the base of the Lower *Polygnathus dengleri* Subzone (Klapper and Johnson, 1980, p. 414). In stratigraphic terms for northeastern Alberta, this level would correspond approximately with the base of the Slave Point Formation, a unit which immediately underlies the Waterways Formation in that area.

Biostratigraphy of brachiopods described in this report

The brachiopods described and illustrated in this report are listed in the accompanying table. These are accompanied by occurrences of identical or related forms from other areas for comparison.

	1	2	3	4	5	6	7	8	9	10
Schizophoria allani Warren	cf.									
Schizophoria athabaskensis Warren								cf.		
Schizophoria lata Stainbrook						aff.				X
Schizophoria warreni n. sp.								aff.		
Strophodonta (S.) albertensis n. sp.			cf.		aff.					
Strophodonta (S.) calumetensis n. sp.			cf.						cf.	
Strophodonta (S.) clearwaterensis n. sp.							cf.	cf.		
Strophodonta (S.) dorsata (Stainbrook)										X
Strophodonta (S.) engstromi n. sp.						aff.	cf.	cf.		
Strophodonta (S.) inflexa (Swallow)							X			
Strophodonta (S.) moberliensis n. sp.							cf.	cf.		
Nervostrophia sp.		cf.								
Eostrophalosia pedderi Crickmay				X			cf.			
Devonoproductus catamorphus (Crickmay)										
Devonoproductus reticulocosta n. sp.										
Devonoproductus tertius Crickmay				aff.?						

1 - Peace Point Member of Waterways Formation, Gypsum Cliffs, Peace River, northeastern Alberta; Upper *dengleri* Subzone.
2 - Beds of Waterways Formation on Birch River equivalent to upper Calumet and lower Christina Members of northeastern Alberta; Lower *asymmetricus* Zone.
3 - Middle of Assemblage 4, upper Flume Formation, Wallbridge Mountain, east-central British Columbia.
4 - Assemblage 5, uppermost Flume Formation, Cecilia Lake, east-central British Columbia.
5 - Undifferentiated carbonate beds of Point Wilkins Member of Souris River Formation, outcrop belt of southwestern Manitoba; Upper *dengleri* Subzone.
6 - Uppermost Petoskey Formation, Michigan, possibly equivalent to Squaw Bay Formation or slightly higher beds; Lower *asymmetricus* Zone or slightly younger.
7 - Snyder Creek Shale of Missouri; Upper *dengleri* Subzone to Middle *asymmetricus* Zone.
8 - Lower Rapid Member of Cedar Valley Limestone, Iowa; "*Atrypa*" *bellula* Zone; Lower *hermanni-cristatus* Subzone.
9 - About middle of Rapid Member, Cedar Valley Limestone, Iowa; *Pentamerella* beds; ?Upper *hermanni-cristatus* Subzone.
10 - Upper Rapid Member, Cedar Valley Limestone, Iowa; "*Atrypa*" *waterlooensis* Zone; ?Upper *hermanni-cristatus* Subzone.

X - identical. cf. - similar, possibly conspecific. aff. - closely related. aff.? - related, but not conspecific.

One form, *Schizophoria warreni* n. sp., occurs only in the lower part of the Firebag Member of the Waterways Formation. It shows some similarity to young growth stages of *Schizophoria iowensis* Hall, a species described and illustrated by Stainbrook (1940, p. 483 - 486, Pl. 1, figs. 1 - 10) from the '*Spinatrypa*' *bellula* Zone of the lower Rapid Member of the Cedar Valley Limestone of Iowa. This interval in Iowa is collated with the Lower *Schmidtognathus hermanni - Polygnathus cristatus* Subzone (Klapper et al., 1971, p. 298, fig. 3, column 4). The occurrence of *Schizophoria warreni* in the Firebag Member of the Waterways Formation of northeastern Alberta is within the brachiopod *Eleutherokomma impennis* Zone of Crickmay (1957, 1966), and within the conodont *Pandorinellina insita* Fauna of Uyeno (1974), which in turn has been aligned with the Upper *Polygnathus dengleri* Subzone of Klapper and Johnson (1980).

One form, *Schizophoria lata* Stainbrook, occurs in the Firebag, Calumet and probably in the Christina members of the Waterways Formation. This form occurs typically in the "*Atrypa*" *waterlooensis* Zone of the upper Rapid Member of the Cedar Valley Limestone of Iowa, an interval that probably collates with the Upper *Schmidtognathus hermanni - Polygnathus cristatus* Subzone. The range of *Schizophoria lata* in the Waterways Formation is through the upper half of the *Eleutherokomma impennis* Zone, and through the "*Stropheodonta costata*" Zone, into the lower part of the *Eleutherokomma* cf. *jasperensis* Zone of Crickmay (1957, 1966). In terms of conodont zonation of Uyeno (1974) and Klapper and Johnson (1980) this range is within the upper part of the Upper *Polygnathus dengleri* Subzone, through the Lower *Polygnathus asymmetricus* Zone into the lower part of the Middle *Polygnathus asymmetricus* Zone.

Nine of the species described and illustrated in this report are from the Calumet Member of the Waterways Formation and these comprise: *Schizophoria allani* Warren, *Schizophoria athabaskensis* Warren, *Strophodonta (Strophodonta) albertensis* n. sp., *Strophodonta (S.) calumetensis* n. sp., *Strophodonta (S.) clearwaterensis* n. sp., *Strophodonta (S.) dorsata* (Stainbrook), *Strophodonta (S.) engstromi* n. sp., *Strophodonta (S.) inflexa* (Swallow) and *Nervostrophia* sp. Two of these, *Strophodonta (S.) dorsata* (Stainbrook) and *Strophodonta (S.) inflexa* (Swallow), occur typically elsewhere. The former form is recorded by Stainbrook (1938, p. 255) from the "*Atrypa*" *waterlooensis* Zone, upper Rapid Member of the Cedar Valley Limestone of Iowa, which is within an interval undated by conodonts but possibly may be assigned to the Upper *Schmidtognathus hermanni - Polygnathus cristatus* Subzone

(see Klapper et al., 1971, p. 298, fig. 3), and the recently recognized Lower *Polygnathus dengleri* Subzone of Klapper and Johnson (1980) as well. The latter form, *Strophodonta (S.) inflata* (Swallow), occurs typically in the Snyder Creek Shale of Missouri (Branson, 1922, p. 81), an interval that is collated by Schumacher (1976, p. 160, fig. 1) with the Lowermost *Polygnathus asymmetricus* Zone (=Upper *Polygnathus dengleri* Subzone) to the Middle *Polygnathus asymmetricus* Zone.

The nine species of this report confined to the Calumet Member of the Waterways Formation are within the brachiopod "*Strapheodonta costata*" Zone of Crickmay (1957, 1966). Norris (Norris and Uyeno, 1981) has pointed out that this is an undesirable zone name because the form suggestive of *S. costata* in the Waterways Formation is much younger than the typical Iowa form. The form in the Calumet Member having the closest affinity to the Iowa form is here named *Strophodonta (Strophodonta) clearwaterensis* n. sp. and is suggested as a replacement for the *Strapheodonta costata* Zone name. An alternative name suggested by Norris (Norris and Uyeno, 1981) to apply to the Calumet megafauna is *Ladogioides amenista* fauna, named after a distinctive rhynchonellid brachiopod that occurs within the Calumet Member. The Calumet Member has been collated by Uyeno (1974) with the upper part of the Upper *Polygnathus dengleri* Subzone of Klapper and Ziegler (1980) and most of the succeeding Lower *Polygnathus asymmetricus* Zone.

The unusually abundant and stratigraphically complete collections of *Schizophoria* and *Strophodonta (Strophodonta)* in the Calumet Member of the Waterways Formation appear to involve continuous variation between extreme morphologic types. Although there is some apparent connection with forms in the Cedar Valley Limestone of Iowa and the Snyder Creek Shale of Missouri, most of the Calumet forms are interpreted as a record of endemic evolution rather than migration. It is here that one is faced with the quandary of arbitrarily separating what appears to be a biological continuum in some cases.

One form, *Devonoproductus reticulocostus* n. sp., ranges from the upper part of the Calumet Member, where it occurs sparingly, into the lower half of the Moberly Member of the Waterways, where it appears to be slightly more abundant. The range of *Devonoproductus reticulocostus* in terms of brachiopod zonation is from the upper part of the *Strophodonta clearwaterensis* Zone [=*Strapheodonta costata* Zone of Crickmay (1957, 1966)], through the *Eleutherokomma* cf. *jasperensis* Zone into the lower part of the *Eleutherokomma hamiltoni* Zone of Crickmay (1957, 1966). This interval in terms of conodont zonation by Uyeno (1974) ranges from the upper part of the Lower *Polygnathus asymmetricus* Zone into approximately the lower third of the Middle *Polygnathus asymmetricus* Zone.

Four species, comprising *Strophodonta (Strophodonta) moberlensis* n. sp., *Eostrophalosia pedderi* Crickmay, *Devonoproductus catamorphus* (Crickmay), and *Devonoproductus tertius* Crickmay, have been recorded in this study only from the lower half of the Moberly Member. The range of these four species in terms of the brachiopod zonal scheme of Crickmay (1957, 1966) is from the upper part of the *Eleutherokomma* cf. *jasperensis* Zone to the lowermost part of the *Eleutherokomma hamiltoni* Zone. In the conodont zonal scheme this interval is within the lower half of the Middle *Polygnathus asymmetricus* Zone of Uyeno (1974) for the Waterways Formation.

The reported occurrence of *Eostrophalosia pedderi* Crickmay by Raasch (Maurin and Raasch, 1972 Pl. 3) from his Assemblage 5 in the uppermost Flume Formation at Cecilia Lake, east-central British Columbia, suggests a correlation of the upper part of the lower half of the Moberly Member of the Waterways Formation of northeastern Alberta with the uppermost Flume Formation at Cecilia Lake.

SYSTEMATIC PALEONTOLOGY

All specimens illustrated in this report have been assigned type GSC numbers and will be placed in the national type collection curated by the Geological Survey of Canada in Ottawa.

For easy reference, locality data accompanies the description of each taxon rather than being placed under a separate index of Localities.

Phylum Brachiopoda Dumeril, 1806

Class Articulata Huxley, 1869

Order Orthida Schuchert and Cooper, 1932

Superfamily Enteletacea Waagen, 1884

Family Enteletidae Waagen, 1884

Subfamily Schizophoriinae Schuchert and Levine, 1929

Genus *Schizophoria* King, 1850, p. 106

Type species: (*Conchyliolithus (Amonites) resupinatus* Martin, 1809, Pl. 49, figs. 13, 14; OD)

Schizophoria aliani Warren
Plate 1, figures 1 - 16

1944 *Schizophoria aliani* Warren, p. 109, Pl. 1, figs. 4, 5
1956 *Schizophoria aliani* Warren; Warren and Stelck, Pl. 11, figs. 1 - 3

Material. This is a relatively rare form in the Waterways Formation of northeastern Alberta and judging from large collections from this area the most abundant and best material is from the Calumet Member.

Dimensions.

	GSC No.			
	58739	58740	58741	58742
	(mm)			
GSC locality	29266	29266	29075	29266
Length of pv (Lpv)	29.3	32.2	31.1	35.1
Length of bv (Lbv)	29.7	35.0	31.4	40.6
Width (W)	31.1	34.7	36.9	44.9
Depth (D)	24.4	25.3	25.3	33.6
Width of pedicle interarea (Wpi)	13.2	16.0	—	—
Depth of sulcus at anterior margin	16.4	12.4	14.5	20.9
Ratio: W/Lpv	1.06	1.08	1.19	1.28
Ratio: W/Wpi	2.58	2.17	—	—
Costae per 5 mm, 10 mm from beak	pv 13 bv —	pv 17 bv 14	pv 15 bv 15	pv 15 bv 13
Costae per 5 mm, 20 mm from beak	pv 12 bv —	pv 14 bv 15	pv 15 bv 12	pv 13 bv 13

Description. Shell attains a medium to large size at maturity, strongly but unequally biconvex, the brachial valve generally accounting for three-quarters or more of total depth of shell, subcircular in outline, slightly wider than long, ratio of width to length of pedicle valve amongst figured specimens varies from 1.06 to 1.28, greatest width near or more commonly anterior of midlength, anterior margin moderately to strongly indented by mesial sinus in pedicle valve. Width of hinge line is about one-quarter to one-fifth that of shell.

Pedicle valve weakly convex, highest at or immediately anterior of the umbo, broadly and moderately convex in umbonal region, strongly convex toward the cardinal margins, lateral flanks relatively flat. A midial sinus gradually appears posterior of midlength which deepens, widens, and becomes more angular anteriorly to form a rounded V-shaped lingual extension in the brachial valve. Beak is of medium size, pointed, incurved and generally projected beyond that of the opposite valve. Interarea is broadly triangular, flat near the hinge line, curved beneath the beak, distinct at lateral margins, marked by transverse growth striations; apsacline toward hinge line, becoming orthocline toward the beak, completely covered by opposite valve in gerontic specimens. Delthyrium is narrowly triangular, open.

Brachial valve very strongly convex, highest between one-third and one-half length from beak, very strongly arched transversely, lateral flanks steep, surface curving rapidly over and beneath the umbo to the cardinal margins. Umbonal region is highly inflate and extremely prominent, extended beyond the hinge line. Beak short, pointed, incurving, partially or completely concealed by beak of the opposite valve; area broadly triangular, low, curved, apsacline, completely covered in gerontic specimens.

Interiors of both valves not seen.

Surface of both valves marked by fine, uniform, round crested radial costellae which increase in number anteriorly by bifurcation and intercalation; they are separated by flat-bottomed troughs of equal or greater widths. Concentration of costae varies from 13 to 17 and averages 14.6 per 5 mm of arc at 10 mm from the beak; at 20 mm from the beak the concentration varies from 12 to 15 and averages 13.4 per 5 mm of arc. Concentric growth lines are irregularly spaced but are more numerous and closely spaced toward the anterior and lateral margins of the valves. Hollow costellae are evident where these have been abraded. Shell substance is very finely punctate.

Comparison. *Schizophoria allani* Warren is somewhat similar in shape outline to *Schizophoria meeki* Fenton and Fenton (1928, p. 160 - 162, Pl. 1, figs. 1 - 3; Stainbrook, 1940, p. 490 - 492, Pl. 1, figs. 11, 15 - 20) which occurs in the *"Atrypa independensis"* Zone in the lower part of the Cedar Valley Formation of Iowa. *Schizophoria allani* differs from the Iowa form in attaining a much larger size at maturity, in having a more pronounced indented anterior margin, a deeper and more conspicuous rounded V-shaped sulcus in the pedicle valve, and a tendency to have more flared and wider lateral flanks on the brachial valve.

From *Schizophoria macfarlanei* (Meek, 1868, p. 88 - 90, Pl. 12, figs. 1a - 1g) from Middle Devonian beds of the lower Mackenzie River region, *Schizophoria allani* is distinguished by its proportionately broader outline, by its less inflate pedicle valve, by its proportionately narrower and more acute brachial umbo, as well as other shape differences. Pedder (1975, p. 574) has indicated that *Schizophoria macfarlanei* (Meek) is a diagnostic element of the *Leiorhynchus hippocastanea* Zone in the upper part of the platform beds of the Ramparts Formation of the lower Mackenzie River region where it is associated with conodonts now placed by Klapper and Johnson (1980) in the Lower *Polygnathus dengleri* Subzone.

Occurrence. The type specimens of *Schizophoria allani* were recorded by Warren (1940, p. 110) from beds of the Waterways Formation on Athabasca River near Fort McMurray which would place them within the Moberly Member if they were collected from outcrops. Later, *Schizophoria allani* was placed by Warren and Stelck (1950, p. 71; 1956, Pl. 11) in their *'Allanaria' allani* Zone of the Waterways Formation, which was indicated as occurring above their *Lingula* cf. *spatulata* Zone and below their *Eleutherokomma hamiltoni* Zone. Judging from their (Warren and Stelck, 1950, p. 71) faunal list it is apparent that they included faunas of the Calumet, Christina and Moberly members of the Waterways Formation within their *allani* Zone.

This species is not abundant in the Waterways Formation but is best represented in beds of the Calumet Member of the Waterways Formation which outcrop along the upper Clearwater River and at one locality on the lower Athabasca River. A single specimen of a closely related form designated as *Schizophoria* sp. cf. *S. allani* Warren has been recorded by Norris (Norris and Uyeno, in press) from the Peace Point Member (=lower part of Firebag Member) of the Waterways Formation at Gypsum Cliffs on Peace River in northeastern Alberta.

Figured specimens. GSC 58739, 58740 and 58742 from GSC locality 29266; and GSC 58741 from GSC locality 29075.

Locality data. GSC locality 29266 (sample 310NBa) from station 101NB-56, west bank of Athabasca River, 0.3 km below mouth of Pierre River, Calumet Member, unit a, 1.5 m above river level, estimated at 4.5 m above base of member.

GSC locality 29075 (sample 107NBc) from station 178NB-56, north bank of Clearwater River, 9.3 km straight line distance below mouth of Cottonwood Creek, Calumet Member, unit 2, 1.5 m above river level, estimated to be about 24.3 m above base of member.

Schizophoria athabaskensis Warren
Plate 1, figures 17 - 26; Plate 2, figures 1 - 17

1868	*Orthis lowensis* Hall?; Meek, p. 90, Pl. 12, figs. 2a - 2h
1891	*Orthis striatula* Schlotheim; Whiteaves, p. 218 (part)
1944	*Schizophoria athabaskensis* Warren, p. 110, Pl. 1, figs. 2, 3 (Syntypes D827 and D828)
1952MS	*Schizophoria athabaskensis* Warren; Bassett, p. 129, Pl. 1, figs. 15 - 18
1956	*Schizophoria athabascensis* Warren and Stelck, Pl. 11, figs. 11 - 13 (Syntype Dv831)

Material. Represented by moderately abundant specimens in the Calumet Member and by a few specimens in the Moberly Member of the Waterways Formation.

Dimensions.

	GSC No.						
	58732	58733	58734	58735	58736	58737	58738
	(mm)						
GSC locality	46183	45979	29075	45999	46170	29239	29331
Length of pv (Lpv)	16.9	27.1	30.9	31.0	37.5	35.1	–
Length of bv (Lbv)	16.9	26.9	31.0	32.8	37.0	–	–
Width (W)	17.7	32.7	37.2	39.8	44.3	41.9	–
Depth (D)	8.9	17.9	22.2	21.8	27.2	–	–
Width of pedicle interarea (Wpi)	9.1	16.5	18.2	20.3	21.0	20.2	–
Depth of sulcus at anterior margin	0.9	9.1	9.5	10.6	11.9	8.5	–

	58732	58733	58734	58735	58736	58737	58738
				(mm)			
Ratio W/Lpv	1.19	1.21	1.20	1.27	1.18	1.19	—
Ratio W/Hpi	1.15	2.26	2.09	1.99	2.07	2.07	—
Costae per 5mm, 10 mm from beak	pv 16 bv 13	pv 17 bv —	pv 15 bv 15	pv 15 bv 20	pv 16 bv 12	pv — bv —	pv — bv 17
Costae per 5 mm, 20 mm from beak	pv — bv —	pv 11 bv 11	pv 12 bv 11	pv 13 bv 15	pv 12 bv 12	pv — bv —	pv — bv —

Description. Shell attains a large size at maturity, unequally biconvex, with the brachial valve accounting for two-thirds or more of total depth of shell. Transversely subovate in outline, shell is wider than long, ratio of width to length of pedicle valve varies from 1.18 to 1.27 amongst figured specimens, greatest width near or anterior of midlength, anterior margin rectimarginate in young specimens, moderately uniplicate in adult stages, some adult specimens slightly indented at medial anterior margin.

Pedicle valve is moderately convex with greatest convexity immediately anterior of the beak, reversing curvature postero-laterally toward the cardinal margins, flanks relatively flat. A broad shallow sinus starts at about midlength of valve, that gradually deepens and widens anteriorly to form a broadly rounded V-shaped lingual extension in the opposite valve; beak prominent, slightly inturned; umbo slightly inflated, relatively flat along midline; interarea relatively high, width varying from slightly less than to slightly greater than one-half width of shell, slightly to moderately curved, apsacline toward the hinge line, orthocline toward the apex of beak; delthyrium open, narrowly triangular, with angle at the apex varying between 40 and 50 degrees.

Brachial valve is very strongly convex, highest at about one-third to one-half length of valve, lateral flanks sloping steeply, gently convex, umbo highly inflate, broadly convex; commonly extended posteriorly beyond apex of flank of opposite valve, beak small, strongly inturned; interarea broad, commonly much lower than that of the opposite valve, strongly arched, apsacline.

Both valves are ornamented by very fine radiating hollow costellae that increase in number anteriorly by bifurcation and intercalation. The costellae are round crested and are separated by rounded troughs of about equal or greater width. Concentration of costellae varies from 12 to 20 and averages 15.4 per 5 mm of arc at 10 mm from beak; at 20 mm from the beak the concentration varies from 11 to 15 and averages 12.1 per 5 mm of arc. The oval punctae mentioned by Warren (1944, p. 111) are actually truncated costellae showing the hollow interiors. Shell substance is very finely punctate. Superimposed on the costellae are very fine striations evident on better preserved parts of shell.

Interior of a large mature pedicle valve (Pl. 2, fig. 16) with muscle scars that are broadly flabellate in outline, and with a median anterior emargination; the muscle scars are sharply defined laterally and anteriorly by a bounding ridge that rises obliquely from the floor of the valve which is continuous posteriorly with the dental lamellae; the scars are divided longitudinally by a broad adductor ridge which appears near the beak and increases in height anteriorly to the emargination of the muscle area. It is slightly indented along the midline; a low rounded ridge extends for a short distance along the midline anterior of the muscle area; surrounding most of the interior of the valve is a raised marginal rim between about 2 and 3 mm wide; ovarian-like markings are present throughout most of the interior of the valve between the marginal rim and muscle scar area.

Interior of brachial valve (Pl. 2 fig. 17) with strong brachiophores that are continuous with their supporting plates, nearly vertical, strongly divergent, continued forward slightly as lateral margins of the muscle field; cardinal process small, sharply elevated above the floor of the notothyrial cavity, posterior part with fine 'herring-bone'-like striations, anterior part is a smooth ridge that disappears anteriorly within the notothyrial cavity; low elevations on each side of the cardinal process; muscle area quadripartite, the anterior pair of adductors being separated from the posterior pair by faint oblique ridges extending anterolaterally from the broad median ridge; peripheral margins of muscle area slightly elevated; pallial sinuses prominent.

Remarks and comparison. *Schizophoria athabaskensis* Warren is distinguished from the associated *Schizophoria allani* Warren by its proportionately broader outline, by its relatively broadly rounded V-shaped uniplicate anterior margin rather than a relatively narrow rounded V-shaped anterior margin, and by its broader and less inflate brachial umbo.

Schizophoria iowensis Hall as described and illustrated by Stainbrook (1940, p. 483 - 486 , Pl. 1, figs. 1 - 10) from the "*Atrypa*" *bellula* Zone of the Rapid Member of the Cedar Valley Formation of Iowa is somewhat similar to *Schizophoria athabaskensis* Warren from the Waterways Formation. The latter species attains a much larger size at maturity, has a much more inflated and more inturned brachial umbo, a smaller and less pronounced pedicle umbo, and a stronger emargination on the front of the valves produced by the sinus.

Occurrence. The form designated as *Orthis iowensis* Hall? by Meek (1868, p. 90 - 91, Pl. 12, figs. 2a - 2h) was recorded from the mouth of the Clearwater River on Athabasca River.

The form designated as *Orthis striatula* Schlotheim by Whiteaves (1891, p. 218 - 219, 247) was recorded from the Clearwater River, 6.4 or 8.0 km below the mouth of Pembina River (=Christina River), which would place it in the lower part of the Moberly Member; and from the Athabasca River, 4.8 km below the Calumet River, which is an outcrop of the Calumet Member.

Bassett's (1952MS, p. 129 - 130, Pl. 1, figs. 15 - 18) figured specimen of *Schizophoria athabaskensis* Warren was collected from the north bank of Clearwater River (his station 14-51, shown on his fig. 9) about 19 km above the mouth of Christina River which is from beds of the Calumet Member.

Warren (1944, p. 111) recorded this species from outcrops of the Waterways Formation on Athabasca River near McMurray, Alberta. A syntype of the species was later illustrated by Warren and Stelck (1956, Pl. 11, figs. 11 - 13) as part of the "*Allanaria*" *allani* fauna of the Waterways Formation at McMurray, Alberta. From the above information one would assume that Warren's material came from the Moberly Member of the Waterways Formation. However, the present study indicates that *Schizophoria athabaskensis* occurs mainly in the Calumet Member of the Waterways Formation which outcrops on the upper Clearwater and lower Athabasca rivers. Only a few specimens suggestive of *S. athabaskensis* have been noted in beds of the Moberly Member of the Waterways Formation.

Figured specimens. GSC 58732 from GSC locality 46183, GSC 58733 from GSC locality 45979, GSC 58734 from GSC locality 29075, GSC 58735 from GSC locality 45999, GSC 58736 from GSC locality 46170, GSC 58737 from GSC locality 29239, and GSC 58738 from GSC locality 29335.

Locality data. GSC locality 46183 (sample 119NBc) from station 119NB-61 (=101NB-56), on west bank of Athabasca River, 0.3 km below mouth of Pierre River, Calumet Member, unit 4, 5.1 m above river level, estimated at 9.7 m above base of member.

GSC locality 45979 (sample 17NBa) from station 17NB-61, on north bank of Clearwater River, 1.6 km straight line distance above mouth of Cottonwood Creek, Calumet Member, unit 1, 3.0 m above river level, estimated at 10.5 m above base of member.

GSC locality 29075 (sample 107NBc) from station 178NB-56, on north bank of Clearwater River, 9.3 km straight line distance below mouth of Cottonwood Creek, Calumet Member, 1.5 m above river level, estimated at 24.3 m above base of member.

GSC locality 45999 (sample 24NBb) from station 24NB-61 (=178NB-56), on north bank of Clearwater River, 9.3 km straight line distance below mouth of Cottonwood Creek, Calumet Member, 6.0 m above river level, estimated at 24.9 m above base of member.

GSC locality 46170 (sample 119NBg) from station 119NB-61 (101NB-56), on west bank of Athabasca River, 0.3 km below mouth of Pierre River, Calumet Member, unit 2, 1.1 m above river level, estimated at 5.6 m above base of member.

GSC locality 29239 (sample 312NBc) from station 102NB-56, on west bank of Athabasca River 1.1 km below mouth of Pierre River, Calumet Member, unit -c, 1.9 m above river level, estimated at 8.1 m above base of member.

GSC locality 29335 (sample 105NBd) from station 171NB-56, on north bank of Clearwater River, 1.6 km straight line distance above mouth of Cottonwood Creek, Calumet Member, unit 1, 1.3 m above river level, estimated at 4.9 m above base of member.

Schizophoria lata Stainbrook
Plate 2, figures 18 - 26; Plate 3, figures 1 - 15

1940	*Schizophoria lata* Stainbrook, p. 488, Pl. 2, figs. 1 - 7, 15, 16
1944	*Schizophoria lata* Stainbrook; Warren, p. 109, Pl. 1, fig. 1
1956	*Schizophoria lata* Stainbrook; Warren and Stelck, Pl. 11, figs. 8 - 10
in press	*Schizophoria lata* Stainbrook; Norris in Norris and Uyeno, Pl. 2, figs. 1 - 22

Material. This species is abundantly represented in the Waterways Formation of northeastern Alberta, being moderately abundant in the Firebag Member, extremely abundant in the Calumet Member, and sparse in the Moberly Member.

Dimensions.

	58724	58725	58726	GSC No. 58727	58728	58729	58730
				(mm)			
GSC locality	46187	46276	45981	46187	46170	46187	45982
Length of pv (Lpv)	8.7	16.3	22.7	29.5	36.9	27.3	50.3
Length of bv (Lbv)	8.7	16.2	22.2	30.3	34.2	—	55.3
Width (W)	11.6	20.8	26.8	38.7	44.2	30.6	60.6
Depth (D)	5.1	8.6	12.8	16.3	22.6	—	25.3
Width of pedicle interarea (Wpi)	8.1	11.5	10.6	20.7	21.6	17.6	31.3
Depth of sulcus at anterior margin	0	0	5.0	8.0	10.9	5.5	12.8
Ratio W/Lpv	1.31	1.28	1.18	1.31	1.27	1.12	1.12
Ratio W/Wpi	1.61	1.81	2.52	1.87	2.07	1.76	1.94
Costae per 5 mm, 10 mm from beak	pv — bv —	pv 18 bv 21	pv 19 bv 25	pv 16 bv 12	pv 13 bv 20	pv 16 bv —	pv 11 bv 13
Costae per 5 mm, 20 mm from beak	pv — bv —	pv — bv —	pv 15 bv 17	pv 12 bv 12	pv 13 bv 19	pv 12 bv —	pv 14 bv 13

Description. Shell attains a medium to large size at maturity, unequally biconvex, transversely subelliptical in outline with rounded postero- and antero-lateral margins, wider than long, ratio of width to length of pedicle valve amongst figured specimens varying between 1.12 to 1.31, broadest about midlength, rectimarginate in young stages, moderately uniplicate in adult stages.

Pedicle valve gently convex, highest along the midline a short distance anterior of the beak, sharply curved from the umbo to the lateral margins, and gently and evenly curved to the lateral margins. A broad, shallow mesial sinus originates about midlength on mature specimens; it widens and deepens toward the front where it is extended as a U-shaped tongue in the opposite valve. Umbo low, broadly convex, tapering toward the apex; beak relatively large, pointed, slightly incurving, elevated, and extended slightly beyond that of the opposite valve; interarea high, relatively narrow, broadly triangular, sharply defined at the edges, very gently incurved toward the beak, apsacline; delthyrium narrowly triangular, open.

Brachial valve considerably more convex than the pedicle valve especially in adult specimens, accounting for about two-thirds depth of shell, umbonal region broadly and strongly convex, concave toward the cardinal margins, flanks moderately steep, gently convex, flattened mesially, a slight suggestion of a fold on a few specimens near the mesial anterior margin; beak pointed in very young specimens, becoming blunt in older specimens, very slightly incurved toward the apex in older specimens, orthocline to slightly apsacline.

Exterior of both valves marked by numerous very fine radiating costellae which increase in number anteriorly by bifurcation and intercalation. The costellae are hollow, round crested and separated by rounded troughs of about equal or less width than the costellae. Concentration of costellae varies from 11 to 25 with an average of 16.5 per 5 mm of arc at 10 mm from the beak; at 20 mm from the beak the concentration varies from 12 to 19 with an average of 14.1 per 5 mm of arc. Concentric growth lines are weakly developed and occur at irregular intervals but are more common and more closely spaced toward the anterolateral margins of mature adult and gerontic specimens. Very fine closely spaced punctae are evident on abraded parts of shell.

Interior of pedicle valve (see Pl. 3, fig. 14) with deep delthyrial cavity, teeth moderately strong, supported by stout dental lamellae, which are extended around the margins of the muscle area as a low ridge; muscle area bilobate or obcordate; diductor scars obliquely divergent, separated by a ridge beginning forward of the apex and widening and increasing in height anteriorly to the emargination of the muscle area, beyond this point ridge abruptly decreases in size and terminates in the anterior quarter of the valve; adductors small, borne on the thickened part of median ridge; pustular markings occur in the posterior part of shell on each side of the muscle area; a slightly raised rim up to about 3 mm wide occurs around the lateral and anterior margins of the valve.

Interior of brachial valve not seen.

Comparison. The form designated as *Schizophoria lata* Stainbrook from the Waterways Formation is undoubtedly morphologically closely similar to the Iowa species. However, the Waterways form does appear to exhibit a wider range of variability of form than is apparent from Stainbrook's (1940, p. 488 - 489, Pl. 2, figs. 1 - 7, 15, 16) description and illustrations. Within populations of this species from the Waterways Formation there are individuals that attain a much larger size at maturity, some are proportionately slightly thinner, and none exhibit the oblong punctae mentioned by Stainbrook (1940, p. 488) that are scattered over the surface of the valves on the crests of the

costellae and which become more numerous near the growth lines. It is suspected but not proven that these "oblong punctae" are merely costellae that have been differentially eroded and show the hollow interiors of the costellae.

Schizophoria lata Stainbrook from the Waterways Formation is easily distinguished from *Schizophoria warreni* n. sp. by its much larger size at maturity, its transversely subelliptical outline, and by its proportionately thinner lateral outline.

From *Schizophoria allani* Warren, *Schizophoria lata* is distinguished by its proportionately wider and thinner outlines, by its much less inflated brachial umbo, and by its much lower and broadly U-shaped uniplicate rather than narrow V-shaped uniplicate anterior margin.

Schizophoria lata differs from *Schizophoria athabascensis* Warren by its transversely elliptical outline, its much thinner lateral profile, its generally broader and less inflate brachial umbo, and by its generally lower and broader uniplicate anterior margin.

From *Schizophoria* cf. *lata* Stainbrook as described and illustrated by Griesemer (1965, p. 256 - 258, Pl. 2, figs. 5 - 7) from the Lindwurm Member of the Milwaukee Formation at Estabrook Park, Milwaukee, Wisconsin, the Waterways form is distinguished by attaining a much larger size at maturity, by having a more pronounced and rounded uniplicate anterior margin, a wider profile, and generally a less sloping hinge line.

In such features as thin lateral profile, subelliptical shape, and the low gently rounded uniplicate anterior margin, *Schizophoria lata* Stainbrook bears some resemblance to *Schizophoria meeacarina* Imbrie (1959, p. 365, Pl. 48, figs. 15 - 21) from the uppermost Petoskey Formation of Michigan. *Schizophoria lata* from the Waterways Formation of northeastern Alberta differs from the Michigan form by attaining a much larger size at maturity, having more smoothly rounded lateral margins as seen in lateral profile, a proportionately wider delthyrial cavity and a much thinner median ridge in the interior of the pedicle valve.

Occurrence. *Schizophoria lata* Stainbrook (1940, p. 485, occurs typically in the *"Atrypa" waterlooensis* Zone of the Rapid Member of the Cedar Valley Formation of Iowa where it is associated with the *"Stropheodonta lowensis* faunule". The *waterlooensis* beds have not been dated by conodonts but are within an interval underlain by beds assigned to the Lower *Schmidtognathus hermanni - Polygnathus cristatus* Subzone and overlain by beds assigned to the *Pandorinellina insita* Fauna (=Upper *Polygnathus dengleri* Subzone of Klapper and Johnson (1980)). Therefore, it is possible that the *waterlooensis* beds are within the Upper *hermanni-cristatus* Subzone (Klapper in Furnish et al., 1969, p. 9; Klapper in Klapper et al., 1971, p. 298, fig. 3, column 4), and Lower *dengleri* Subzone of Klapper and Johnson (1980) as well.

Schizophoria lata Stainbrook was recorded by Warren and Stelck (1950, p. 71) as part of their *'Allanaria' allani* Zone in the Waterways Formation occurring above the *Lingula* cf. *spatulata* Zone and below the *Eleutherokomma hamiltoni* Zone. They later (Warren and Stelck, 1956, Pl. 11, figs. 8 - 10) illustrated this form as part of their *"Allanaria" allani* Fauna.

Schizophoria lata Stainbrook was recorded by Cricknay (1966, p. 21) from 122 to 130.5 m depths within the *Eleutherokomma impennis* Zone of the Firebag Member in the Bear Rodeo No. 1 well (Lot 5, McMurray Settlement, Tp. 89, R. 9, W4). Cricknay (1966, p. 19 - 20) also recorded *Schizophoria* cf. *lata* Stainbrook from 430 to 461 m depths from the *Stropheodonta costata* Zone of the Calumet Member; and *Schizophoria lata* Stainbrook from 402 to 430 m depths of the lower part of the *Eleutherokomma jasperensis* Zone of the Christina Member in the Bear Biltmore No. 1 well (7-11-87-17-W4).

The Lindwurm Member of the Milwaukee Formation at Estabrook Park, Milwaukee, Wisconsin, containing *Schizophoria* cf. *lata* Stainbrook of Griesemer (1965) is correlated by G.O. Raasch (pers. comm., November 24, 1980) with the *Spinatrypa bellula* Zone of the lower Rapid Member of the Cedar Valley Formation of Iowa. This correlation would suggest that the Lindwurm Member would align approximately with the Lower *Schmidtognathus hermanni - Polygnathus cristatus* Subzone.

Locality 7c for *Schizophoria meeacarina* Imbrie (1959) is from the uppermost Petoskey Formation which appears to be the same beds referred to by Cooper et al. (1942, p. 1776 - 1777) as occurring immediately above the Thunder Bay equivalent, and are possibly equivalent or slightly younger than the Squaw Bay Limestone. According to Bultynck (1976, fig. 2 and table 4) the lower two units ("Dolomite bed" and "Bivalve bed") of the Squaw Bay Limestone are within the *Polygnathus dengleri* Zone (undivided), whereas the upper two units ("Pelmatozoan bed" and "Cephalopod bed") are within the Lower *Polygnathus asymmetricus* Zone. The conodont dating of the Squaw Bay Limestone has been discussed also by Klapper et al. (1971, p. 298, fig. 3, column 6) and Uyeno et al. (1982).

In the Clearwater-Athabasca rivers area of northeastern Alberta, *Schizophoria lata* is present in the Firebag Member, abundant in the Calumet Member, and is sparsely represented in the Moberly Member of the Waterways Formation. In the Gypsum Cliffs area of northern Alberta identical and closely related forms referred to as *Schizophoria lata* Stainbrook and *Schizophoria* sp. cf. *S. lata* Stainbrook by Norris (Norris and Uyeno, in press) occur in beds of the Peace Point Member of the Waterways Formation.

Figured specimens. GSC 58724, 58727 and 58729 from GSC locality 46187; GSC 58725 from GSC locality 46274; GSC 58726 from GSC locality 45981; GSC 58728 from GSC locality 46170; and GSC 58730 from GSC locality 45982.

Locality data. GSC locality 46187 (sample 118NBc) from station 118NB-61 (=102NB-56) on west bank of Athabasca River, 1.1 km below mouth of Pierre River, Calumet Member, unit 3, 4.4 m above river level, estimated at 8.9 m above base of member.

GSC locality 46274 (sample 118NBa) from station 118NB-61 (=102NB-56) on west bank of Athabasca River, 1.1 km below mouth of Pierre River, Calumet Member, loose in unit 1, 1.2 m above river level, estimated at 5.6 m above base of member.

GSC locality 45981 (sample 9NBh) from station 9NB-61 on south bank of High Hill River, 1 km straight line distance from mouth of river, Firebag Member, unit 9, 12 m above river level, estimated at 31.2 m above base of member.

GSC locality 46170 (sample 119NBg) from station 119NB-61 (=101NB-56) on west bank of Athabasca River, 0.3 km below mouth of Pierre River, Calumet Member, unit -2, 1.1 m above river level, estimated at 5.6 m above base of member.

GSC locality 45982 (sample 24NBa) from station 24NB-61 (=178NB-56) on north bank of Clearwater River, 9.3 km below mouth of Cottonwood Creek, Calumet Member, loose unit 1, 0.3 m above river level, estimated at 19.4 m above base of member.

Schizophoria warreni n. sp.
Plate 3, figures 16 - 29

Material. Represented by 22 specimens, all from a single locality.

Dimensions.

	GSC No.		
	Paratype 58721	Holotype 58722	Paratype 58723
		(mm)	
GSC locality	46195	46195	46195
Length of pv (Lpv)	18.7	21.0	21.0
Length of bv (Lbv)	18.6	19.8	20.4
Width (W)	20.6	22.0	23.0
Depth (D)	12.5	15.8	16.4
Width of pedicle interarea (Wpi)	9.8	13.0	12.1
Depth of sulcus at anterior margin	2.6	5.0	7.0
Ratio: W/Lpv	1.10	1.05	1.10
Ratio: W/Wpi	2.10	1.69	1.90
Costae per 5 mm, 10 mm from beak	pv 18 bv 17	pv 19 bv 22	pv 17 bv 19

Description. Shell of small size at maturity, strongly but unequally biconvex, suborbicular in outline, very slightly wider than long, with the greatest width at about midlength.

Pedicle valve moderately convex, moderately arched from beak to front with curvature increasing anteriorly, highest between one-quarter and one-third length from beak, weakly arched transversely, a shallow relatively broad sinus is developed in the antero-median quarter to third of valve which is extended as a broad rounded V-shaped tongue in opposite valve; umbo conspicuous, narrowly convex, extended beyond hinge line; beak of small size, pointed, incurved, projected beyond that of the opposite valve; interarea relatively high, narrow, slightly greater than one-half width of shell, flat near the hinge line, curved beneath the beak, round-edged laterally; apsacline, approaching orthocline toward the beak; delthyrium narrowly triangular, open, rounded at the apex.

Brachial valve strongly convex, accounting for more than two-thirds depth of shell, highest at about one-third length of valve from apex; lateral flanks steep; some specimens with very weakly developed broad fold straddling the midline; umbonal region relatively narrow, moderately to strongly inflated and extended posteriorly beyond the hinge line; beak short, pointed, incurving, extended ventrally beyond the hinge line; interarea low, curved, apsacline.

Interior of both valves not known.

Surface of both valves ornamented with numerous very fine, rounded, radiating costae which increase anteriorly by division. The costae are separated by rounded troughs which are as wide or wider than the costae. Concentration of costae vary between 17 and 22 and average 18.7 per 5 mm of arc at 10 mm from the beaks. Concentric growth lines are weak, irregularly spaced, and more conspicuous and closely spaced toward the front of the valves. Interarea of pedicle covered by transverse closely spaced growth markings. Very fine closely spaced punctae evident on abraded parts of shell.

Remarks and comparison. *Schizophoria warreni* n. sp. is somewhat similar to young forms of *Schizophoria iowensis* Hall as described and illustrated by Stainbrook (1940, p. 483 - 486, Pl. 1, figs. 1 - 10) from the *'Spinatrypa' bellula* Zone of the lower part of the Rapid Member of the Cedar Valley Formation of Iowa. *Schizophoria warreni* n. sp. is distinguished from the Iowa form by attaining a smaller size at maturity, by its more inflate and round lateral profile, by its less pointed, more rounded umbo, and by its more circular outline.

Schizophoria warreni n. sp. is easily distinguished from all other *Schizophoria* in the Waterways Formation by its small size at maturity, its suborbicular outline, and by its highly inflate lateral profile.

Occurrence. *Schizophoria warreni* n. sp. is a rare form in the Firebag Member of the Waterways Formation of northeastern Alberta. It has been collected from only one locality on the lower Athabasca River where it is associated with the more numerous *Schizophoria late* Stainbrook and other brachiopods typical of the Firebag Member.

Derivation of name. The trivial name is after the late Dr. P.S. Warren who named the Waterways Formation and who described and illustrated some of the Waterways brachiopods.

Figured specimens. Holotype 58722 and paratypes 58721 and 58723 from GSC locality 46195.

Locality data. GSC locality 46195 (sample 117NBa) from station 117NB-61 (=103NB-56) from the east bank of Athabasca River, 3.5 km below the mouth of Eymundson Creek, Firebag Member, loose in unit 1, 0.7 m above river level, estimated at 17.1 m above base of member.

Superfamily Strophomenacea King, 1846

Family Strophreodontidae Caster, 1939

Subfamily Strophreodontinae Caster, 1939

Genus *Strophodonta* Hall, 1850

Type species: *Leptaena demissa* Conrad, 1842, p. 258 (= Strophreodonta Hall, 1852, p. 63 (nom. van.))

Subgenus *Strophodonta (Strophodonta)* Hall, 1852 emended.

Type species: *Leptaena demissa* Conrad (see above)

Strophodonta (Strophodonta) albertensis n. sp.
Plate 3, figures 30 - 33; Plate 4, figures 1 - 13

1956 *Strophreodonta subdemissa* Hall; Warren and Stelck, Pl. 12, fig. 29

1956 *Strophreodonta lowensis* Owen; Warren and Stelck, Pl. 13, fig. 7

Material. Moderately abundant.

Dimensions.

Description. Shell attains medium size, moderately thin, concavo-convex, subquadrangular in outline, with some specimens showing slightly extended cardinal angles, anterolateral margins rounded with slight indentations immediately anterior of cardinal angles, wider than long with greatest width along the hinge line or anterior of it.

Pedicle valve weakly to moderately convex, highest along the midline, flanks slope gently and evenly to the anterior and lateral margins, on each side of the umbonal region the curvature reverses to become slightly concave toward the cardinal margins; beak is small, sharp, and slightly extended; ventral interarea low, highest beneath the beak and decreasing in height gradually toward the cardinal extremities, slightly curved, anacline.

Brachial valve weakly concave, sloping upward with gentle curvature toward anterior and lateral margins and sharply upturned along cardinal margin; a shallow indistinct depression along the midline which widens anteriorly is present on some specimens; dorsal interarea is very low, catacline, forming an approximate right angle with the opposite interarea.

Both valves ornamented by numerous radiating angular crested uneven costae which increase by division anteriorly and are separated by wider uneven rounded troughs. Some shells display faint parvicostellation. Superimposed on the costae are faint very fine costellae. The bundles of costae radiating from the umbonal region of both valves are more conspicuous than those radiating from the cardinal margins. Concentration of costae at 10 mm from apex averages 8.7 per 5 mm of arc, and at 20 mm from apex averages 7.6 per 5 mm of arc. Coarse concentric growth lines are widely and irregularly spaced.

Comparison. In shape outline, relatively thin lateral profile and fine costation, this form closely resembles "*Strophodonta iowensis* Owen" as described and illustrated by Stainbrook (1938, p. 250, Pl. 34, figs. 3, 4 and 7) from the Cedar Valley Limestone of Iowa in beds equivalent to the *waterloonsis* Zone. It differs from the Iowa form in lacking the distinctive inflated umbo, in attaining a thicker lateral profile, by having slightly thicker and more uneven costae, and by exhibiting a wider range of size and shape outline.

From *Strophodonta subdemissa* Hall, as described and illustrated by Stainbrook (1938, p. 246, Pl. 35, figs. 14, 15, 17, 18) from the "*Atrypa*" *independensis* Zone of the Cedar Valley Limestone of Iowa, *S. (S.) albertensis* n. sp. is distinguished by its more closely spaced and more irregular costae, by its straighter, less sloping hinge line, and by its less inflated pedicle umbo that barely projects beyond the hinge line.

Strophodonta (Strophodonta) albertensis n. sp. is closely related in thin lateral profile and size of costae to a form designated as *Strophodonta* cf. *iowensis* Owen by Raasch (in Maurin and Raasch, 1972, Pls. 1, 3; Pl. 11, figs. 16, 17) in sample 474 from about the middle of his Assemblage 4 (DFR4) in the upper part of the Flume Formation at Wallbridge Mountain, east-central British Columbia. *S. (S.) albertensis* n. sp. is distinguished from the Wallbridge Mountain form by finer and more closely spaced costae, by a less inflated pedicle umbo, and lower interareas on the pedicle and brachial valves.

The form designated as *Strophodonta costata* Owen by Raasch (in Maurin and Raasch, 1972, Pl. 2, fig. 18) in sample 473 from near the middle of his Assemblage 4 in the upper part of the Flume Formation at Wallbridge Mountain, appears to be a young individual of the form designated as *Strophodonta* cf. *iowensis* by Raasch.

Some of the variant forms here included in *Strophodonta (Strophodonta) albertensis* n. sp., particularly holotype 58689, are closely comparable in shape outline, lateral profile and fine costae to the form designated as *Strophodonta* sp. by McCammon (1960, p. 46, 47, Pl. 7, figs. 8a, 8b) from the Souris River Formation (locality 9) of Manitoba. The beds at locality 9 are considered part of the Undifferentiated carbonate beds of the Point Wilkins Member of the Souris River Formation by Norris, Uyeno and McCabe (in press). *Strophodonta (Strophodonta) albertensis* n. sp. is distinguished from the Manitoba form by having a thinner lateral profile, a less inflated pedicle umbo, and a proportionately wider hinge line.

On such features as shape outline, thin lateral profile and fine costae, *Strophodonta (Strophodonta) albertensis* n. sp. bears some resemblance to *Strophodonta levidensa* Imbrie (1959, p. 384, Pl. 56, figs. 6 - 10) and *S. rhabdosis* Imbrie (1959) p. 384, Pl. 56, figs. 18 - 22) both from the uppermost Petoskey Formation of Michigan. *S. (S.) albertensis* n. sp. differs from these two species by attaining a much larger size at maturity, having a thicker lateral profile, and by having slightly coarser and more irregular costae.

Elongate forms of *S. (S.) albertensis* n. sp., such as paratype 58688, appear to be closely similar to a finely costate form included in *Strophodonta demissa* (Conrad) by Branson (1922, p. 77, Pl. 14, fig. 8) from the Snyder Creek Shale of Callaway County, Missouri.

S. (S.) albertensis n. sp. is easily distinguished from associated strophodontids in the Waterways Formation by its relatively thin lateral profile and relatively fine costation.

Occurrence. *S. (S.) albertensis* n. sp. is moderately abundant in some beds of the Calumet Member of Waterways Formation outcropping along the upper Clearwater River and occurs less abundantly in Calumet beds outcropping on lower Athabasca River of northeastern Alberta.

Derivation of name. The trivial name is after the Province of Alberta.

Figured specimens. GSC paratypes 58683 and 58688 from GSC locality 46130; GSC paratypes 58684, 58685, 58686, 58687, 58690, and 58691 from GSC locality 45999; and GSC holotype 58689 from GSC locality 46001.

Locality data. GSC locality 46130 (sample 20NBa) from station 20NB-61 (=173NB-56) on north bank of Clearwater River, nearly opposite the mouth of Cottonwood Creek, Calumet Member, loose in unit 1, 0.5 m above river level, estimated at 14. 8 m above base of member.

GSC locality 45999 (sample 24NBh) from station 24NB-61 (=178NB-61) on north bank of Clearwater River, 4.3 km straight line distance below mouth of Cottonwood Creek, Calumet Member, unit 8, 5.9 m above river level, estimated at 24.9 m above base of member.

GSC locality 46001 (sample 19NBb) from station 19NB-61 on north bank of Clearwater River, slightly above mouth of Cottonwood Creek, Calumet Member, unit 3, 3.7 m above river level, estimated at 17.9 m above base of member.

Strophodonta (Strophodonta) calumetensis n. sp.
Plate 4, figures 14 - 24

Material. Represented by relatively few specimens.

Dimensions.

	GSC No. Paratype 58692	Paratype 58693	Holotype 58694	Paratype 58695
		(mm)		
GSC locality	46001	46001	46001	46001
Length of pv (Lpv)	12.4	18.7	22.1	26.4
Length of bv (Lbv)	10.8	15.8	19.9	21.3
Width (W)	16.9	26.3	28.1	28.7
Depth of shell (D)	5.4	8.6	9.7	11.2
Ratio W/Lpv	1.36	1.40	1.27	1.09
Costae per 5 mm, 10 mm from beak	pv 9 bv —	pv 8 bv —	pv 8 bv —	pv 7 bv —
Costae per 5 mm, 20 mm from beak	pv — bv —	pv — bv —	pv 8 bv —	pv 7 bv 7

Description. Shell of medium size, wider than long with greatest width at or slightly anterior of the hinge line, relatively thick, concavo-convex, subelliptical in outline with some forms slightly auriculate and others with a relatively short cardinal margin.

Pedicle valve moderately to strongly convex, highest at or posterior to midlength, the surface sloping thence with moderate curvature to the lateral and anterior margins and more strongly on each side of the umbo, depressed and curvature reversed toward the lateral cardinal extremities; umbonal region mainly moderately but also strongly inflated; beak small, projecting slightly beyond the hinge line. Pedicle interarea very low, highest beneath the beak, gradually decreasing in height toward the extremities, vertically striated, nearly flat in young specimens, moderately curved in older specimens, anacline.

Brachial valve weakly to moderately concave, the surface curving upward evenly and gently from central part to the anterior and lateral margins and much more abruptly to the cardinal margin, flattened and a little elevated at and near the cardinal angles. Interarea marked by weak vertical striations, flat, hypercline.

Surfaces of both valves marked by numerous fine, sharp crested, irregular costae, separated by rounded troughs of equal or greater widths. Increase of costae on pedicle valve is by bifurcation and intercalation. Concentration of costae average 8 per 5 mm of arc at 10 mm from the beak, and average 7.3 per 5 mm of arc at 20 mm from the beak. Superimposed on the costae and troughs are very fine closely spaced radial costellae. Coarse, sparse, irregularly spaced concentric growth markings are present on some specimens. Very fine, closely spaced, microscopic, concentric markings cross the costae and troughs.

Comparison. In shape and fine costation *Strophodonta (Strophodonta) calumetensis* n. sp. somewhat resembles *Strophesodonta parva* Owen as described and illustrated by Stainbrook (1938, p. 245 - 246, Pl. 33, figs. 25 - 27, 32, 33) from the uppermost part of the *Pentamerella* Zone of the Rapid Member of the Cedar Valley Formation of Iowa. It differs from the Iowa species by attaining a larger size at maturity, by being thicker and generally proportionately wider, and by a more inflated and wider umbonal region.

The broader forms included in *Strophodonta (Strophodonta) calumetensis*, such as holotype 56894, are comparable in size of costae and in shape outline to the form indicated as *Strophodonta* cf. *subdemissa* Hall by Raasch (in Maurin and Raasch, 1972, Pl. 11, fig. 19) from sample 473 near the middle of his Assemblage 4 in the upper part of the Flume Formation at Wallbridge Mountain, east-central British Columbia. *S. (S.) calumetensis* can be distinguished from the Wallbridge Mountain form by its more irregular costae and by its more inflated pedicle umbo and more pointed pedicle beak that projects a greater distance beyond the hinge margin.

Strophodonta (Strophodonta) calumetensis is easily distinguished from *S. (S.) albertensis* by its slightly coarser costae and much thicker lateral profile.

Occurrence. Present in beds of the Calumet Member of the Waterways Formation outcropping along the upper Clearwater and lower Athabasca rivers of northeastern Alberta.

Derivation of name. The trivial name is after the Calumet River which empties into the Athabasca River near Mile 55 below the Waterways wharf.

Figured specimens. Paratypes 58692, 58693 and 58695, and holotype 58694, all from GSC locality 46001.

Locality data. GSC locality 46001 (sample 19NBb) from station 19NB-61 on north bank of Clearwater River, slightly above mouth of Cottonwood Creek, Calumet Member, unit 3, 3.7 m above river level, estimated at 18.2 m above base of member.

Strophodonta (Strophodonta) clearwaterensis n. sp.
Plate 4, figures 25 - 38; Plate 5 figures 1 - 4

1868 *Strophomena (Strophodonta) subdemissa* Hall; Meek, p. 88, Pl. 13, figs. 7a - 7c
1956 *Strophesodonta plicata* Hall; Warren and Stelck, Pl. 13, fig. 5
1956 *Strophesodonta* cf. *umbonata* Stainbrook; Warren and Stelck, Pl. 13, figs. 16 - 17

Material. Moderately abundant.

Dimensions.

	GSC No. Paratype 58701	Paratype 58702	Holotype 58703	Paratype 58704	Paratype 58705
			(mm)		
GSC locality	46169	46169	46130	46183	29239
Length of pv (Lpv)	19.7	18.1	26.4	18.8	—
Length of bv (Lbv)	16.0	16.5	22.6	—	13.7
Width (W)	19.7	21.4	29.5	20.0	18.5
Depth of shell (D)	9.4	7.3	13.5	8.8	—
Ratio W/Lpv	1.00	1.18	1.12	1.06	—
Costae per 5 mm, 10 mm from beak	pv 8 bv 8	pv 8 bv 8	pv 7.5 bv 7.5	pv 7.5 bv —	pv — bv 7.5
Costae per 5 mm, 20 mm from beak	pv — bv —	pv — bv —	pv 6 bv 6	pv — bv —	pv — bv —

Description. Shell attains medium size for the genus, generally wider than long with greatest width about midlength, suborbicular, auriculate, with pronounced indentations of the lateral margins immediately anterior of the 'ears', broadly rounded anterior margin.

Pedicle valve subhemispherical in lateral profile with greatest convexity between the beak and the centre of the valve along the midline, curvature fairly regular from this point laterally and anteriorly; umbo slightly to moderately inflated, strongly inturned towards the opposite valve; beak small, blunt; interarea low, wide, equal to width of hinge line, highest beneath beak, moderately curved, orthocline near hinge line, becoming anacline toward beak, longitudinally striated con.. uous with denticulations on the hinge margin.

Brachial valve moderately to strongly concave, much flattened toward the cardinal margin, with some specimens showing a narrow, shallow sinus in the umbonal region; beak very small and inconspicuous; some specimens showing conspicuous depressions where the cardinal extremities are extended; interarea low, gradually decreasing in height laterally, nearly flat, hyperciine.

Interior of pedicle valve (see Pl. 5, figs. 1, 2) has a finely denticulated hinge margin on each side of the ventral process which is broken in the specimen at hand. Two pits for the reception of the cardinal process lie on each side of the ventral process. The quadripartite adductor muscle field is longitudinally elliptical in outline and is divided medianly by a narrow groove posteriorly. The posterior adductors extend laterally of the anterior pair. Two subflabellate, radially fluted diductor scars extend anterolaterally from the adductors to slightly beyond midlength of valve. Lateral boundary ridges are low. A subperipheral rim is weakly developed laterally and anteriorly. The inner surface of the valve outside the muscle fields is marked by tiny pustules.

Interior of brachial valve (Pl. 5, figs. 3,4) shows a low, denticulated hinge margin on each side of the cardinal process, with denticulations extending just short of the 'ears'; the cardinal process is stout with two distinct lobes directed posteriorly almost in line with the plane of the commissure; muscle field is indistinct in specimen at hand, the anterior part of the muscle field is divided longitudinally by a median septum which extends forward to near marginal rim of valve; area surrounding the muscle field laterally and anteriorly is finely pustulose, with pustules arranged in an obscure radiating pattern; interior lateral and anterior rims of valve marked by ridges and furrows.

Both valves ornamented by relatively coarse, radiating, rounded to angular crested costae which increase in number anteriorly by bifurcation and intercalation. Costae are separated by troughs of narrower or about equal width to costae. Concentration of costae varies from 7.5 to 8 per 5 mm of arc at 10 mm from beak. Superimposed on the costae and troughs are very fine closely spaced costellae evident only on better preserved specimens. Growth lines are widely and irregularly spaced and relatively coarse.

Comparison. *Strophodonta (Strophodonta) clearwaterensis* n. sp. is closely comparable to *Stropheodonta equicostata* Swallow as described and illustrated by Branson (1922, p. 79, 80, Pl. 11, fig. 6, Pl. 12, figs. 9 - 17; 1944, Pl. 23, figs. 4, 5, 9 - 11) from the Snyder Creek Shale of Missouri. Schumacher (1976, p. 160, fig. 1) has collated the Snyder Creek Shale of Missouri with the Lowermost (=Upper *Polygnathus dengleri* Subzone), Lower and Middle *Polygnathus asymmetricus* Zones. It is distinguished from the Missouri form by lower pedicle and brachial interareas, a much less inflated pedicle umbo that does not project as much beyond the hinge line as the Missouri form, and by generally having more rounded costae.

Strophodonta (Strophodonta) clearwaterensis n. sp. is also comparable to *Stropheodonta subdemissa* Hall, *Stropheodonta umbonata* Stainbrook, and *Stropheodonta plicata* Hall which occur in the "*Atrypa*" *independensis* Zone of the Solon Member, the "*Atrypa*" *bellula* Zone of the Rapid Member, and the Crassura Zone of the Coralville Member, respectively, of the Cedar Valley Limestone of Iowa (Stainbrook, 1938). *Stropheodonta (Strophodonta) clearwaterensis* n. sp. is distinguished from *Stropheodonta demissa* Hall as described and illustrated by Stainbrook (1938, p. 246 - 247, Pl. 35, figs. 14, 15, 17, 18) by its smaller size at maturity, coarser costae, narrower outline, and thinner lateral profile. From *Stropheodonta umbonata* Stainbrook (1938, p. 252 - 253, Pl. 33, figs. 6 - 9, 19), *Strophodonta (Strophodonta) clearwaterensis* n. sp. is distinguished by its finer costae, its generally less inflated pedicle umbo, and its narrower outline. From *Stropheodonta plicata* Hall (Stainbrook, 1938, p. 246, Pl. 33, figs. 1 - 5, 20), *Strophodonta (Strophodonta) clearwaterensis* n. sp. is distinguished by its generally finer costae, shorter hinge line, and more pronounced indented lateral margins immediately anterior of the hinge line.

Strophodonta (Strophodonta) clearwaterensis n. sp. is presumably the form that Crickmay (1957, 1966) and others have identified as *Stropheodonta costata* Owen from the Waterways Formation of northeastern Alberta. The latter species and *Stropheodonta costata independensis* Stainbrook (1938) occur typically in the "*Atrypa*" *independensis* Zone of the lower Solon Member of the Cedar Valley Formation of Iowa, an interval that is aligned by Ziegler et al. (1976, p. 116, fig. 3) with the upper Middle and lower Upper *Polygnathus varcus* Subzones. *Strophodonta (Strophodonta) clearwaterensis* n. sp. differs from the Iowa species and subspecies by having straighter and more closely spaced costae, a generally much thicker lateral profile, a more concave brachial valve, a differently shaped cardinal process in the brachial valve, and it generally attains a larger size at maturity.

Occurrence. *Strophodonta (Strophodonta) clearwaterensis* n. sp. is one of the more abundant forms present in the Calumet Member of the Waterways Formation along the upper Clearwater River and at one locality on the lower Athabasca River.

Derivation of name. The trivial name is after the Clearwater River.

Figured specimens. Paratypes 58701 and 58702 from GSC locality 46169; holotype 58703 from GSC locality 46130; paratype 58704 from GSC locality 46183; and paratype 58705 from GSC locality 29239.

Locality data. GSC locality 46169 (sample 119NBa) from station 119NB-61 (=101NB-56) on the west bank of Athabasca River, 0.3 km below mouth of Pierre River, Calumet Member, unit 2, 1.9 m above river level, estimated at 6.5 m above base of member.

GSC locality 46130 (sample 20NBa) from station 20NB-61 (=173NB-56) on north bank of Clearwater River, nearly opposite mouth of Cottonwood Creek, Calumet Member, loose in unit 1, 0.5 m above river level, estimated at 14.8 m above base of member.

GSC locality 46183 (sample 119NBc) from station 119NB-61 (=101NB-56) on the west bank of the Athabasca River, 0.3 km below mouth of Pierre River, Calumet Member, unit 4, 5.1 m above river level, estimated at 9.7 m above base of member.

GSC locality 29239 (sample 312NBc) from station 102NB-56 (=118NB-61) on the west bank of Athabasca River, 1.4 km below mouth of Pierre River, Calumet Member, unit -c, 1.9 m above river level, estimated at 8.1 m above base of member.

Strophodonta (Strophodonta) dorsata (Stainbrook)
Plate 5, figures 5 - 18

1938 *Strophodonta dorsata* Stainbrook, p. 254, Pl. 34, figs. 8, 9, 13, 15, 16

1956 *Strophodonta* cf. *dorsata* Stainbrook; Warren and Stelck, Pl. 13, figs. 24 - 26

Material. Common in some beds of the Calumet Member.

Dimensions.

	GSC No.					*S. dorsata* Stainbrook (1938, p. 254)		
	58696	58697	58698	58699	58700			
				(mm)				
GSC locality	46170	46005	46005	46186	46001			
Length of pv (Lpv)	21.5	25.7	29.0	–	–	27.3	30.1	32.6
Length of bv (Lbv)	19.0	21.1	26.3	22.3	25.9			
Width (W)	25.2	31.9	36.9	30.2	31.4	31.5	37.2	37.8
Depth of shell (D)	9.2	12.3	12.0	–	–	11.6	13.3	14.3
Ratio W/Lpv	1.17	1.24	1.27	–	–	1.15	1.24	1.16
Costae per 5 mm, 10 mm from beak	pv 5.5 bv –	pv 5 bv –	pv 8 bv –	pv – bv 8	pv – bv 6			
Costae per 5 mm, 20 mm from beak	pv 5 bv –	pv 5 bv –	pv 7 bv –	pv – bv 7.5	pv – bv 6			

Description. Shell attains medium size at maturity, wider than long with greatest width at or slightly anterior of the hinge line, commonly subquadrate in outline, some specimens subelliptical, cardinal angles rounded and very slightly extended in some specimens, broadly rounded lateral and front margins.

Pedicle valve strongly convex, highest at midlength along the midline, the surface curving uniformly from the midline to the lateral and anterior margins, curvature reverses to become slightly concave towards the posterior lateral margins; umbo moderately to strongly inturned toward the opposite valve; beak small, projecting a short distance beyond the hinge line; interarea low, highest beneath the beak, slightly curved with curvature increasing towards the beak, anacline, approaching catacline toward beak.

Brachial valve moderately to strongly concave; interarea uniformly very low, flat, anacline, forming an approximate right angle with that of the opposite valve.

Costae of both valves moderately coarse, irregular, subangular crested, separated by rounded troughs of equal or greater width, increasing anteriorly by bifurcation and intercalation. Concentration of costae average 6.5 per 5 mm of arc at 10 mm from the beak, and average 6.1 per 5 mm of arc at 20 mm from the beak. Concentric growth lines conspicuous, widely and irregularly spaced; with much finer, almost microscopic, closely spaced concentric lines crossing costae and troughs.

Interior of pedicle valve unknown.

Interior of brachial valve (Pl. 5, figure 18) with a fully denticulate hinge margin on each side of the cardinal process. Cardinal process is stout, with two distinct lobes directed posteriorly at an angle of about 45 degrees to the plane of the commissure. The posterior adductor muscle field is divided longitudinally by a narrow relatively deep trough marking the site of median adductors. The trough changes anteriorly to a median septum that separates the anterior adductor muscle field longitudinally. The median septum continues to about the midpoint of the valve where it terminates in a spindle-shaped elevated area which is depressed in the centre. The areas on the lateral and anterior sides of the muscle scars are coarsely pustulose. An irregular elevated rim about 3 to 4 mm wide extends from the cardinal extremities along the lateral and anterior margins of the interior of the valve and is especially prominent in gerontic individuals.

Comparison. *Strophodonta (Strophodonta) dorsata* Stainbrook is distinguished from the associated *S. (S.) engstromi* n. sp. by its more even and finer costae, by its more inflated lateral profile, and by its generally narrower outline.

From the associated *Strophodonta (Strophodonta) clearwaterensis* n. sp., *S. (S.) dorsata* is distinguished by attaining a much larger size at maturity, by its finer costae, and by its wider outline.

Occurrence. Stainbrook (1938, p. 255) recorded *Strophodonta (Strophodonta) dorsata* from the *"Atrypa" waterlooensis* Zone of the upper part of the Rapid Member of the Cedar Valley Formation of Iowa. This interval has not been firmly dated by conodonts but is probably within the Upper *Schmidtognathus hermanni - Polygnathus cristatus* Zone (Klapper and Collinson in Klapper et al., 1971, p. 298, fig. 3, column 4) and the Lower *Polygnathus dengleri* Subzone of Klapper and Johnson (1980).

Strophodonta dorsata was considered by Warren and Stelck (1950, p. 71) as a constituent of their *Eleutherokomma hamiltoni* Zone which they placed in the upper part of the Waterways Formation exposed along the Athabasca River lying above their *"Spirifer" allani* Zone and below their *Eleutherokomma leducensis* Zone.

In northeastern Alberta, *S. (S.) dorsata* occurs in beds of the Calumet Member of the Waterways Formation outcropping along the upper Clearwater and lower Athabasca rivers.

Figured specimens. GSC 58696 from GSC locality 46170; GSC 58697 and 58698 from GSC locality 46005; GSC 58699 from GSC locality 46186; and GSC 58700 from GSC locality 46001.

Locality data. GSC locality 46170 (sample 119NBg) at station 119NB-61 (=101NB-56) on west bank of Athabasca River, 0.3 km below mouth of Pierre River, Calumet Member, unit 2, 1.1 m above river level, estimated at 5.6 m above base of member.

GSC locality 46005 (sample 23NBi) at station 23NB-61 on north bank of Clearwater River, 8.4 km straight line distance below mouth of Cottonwood Creek, Calumet Member, unit 3, 1.6 m above river level, estimated at 16.9 m above base of member.

GSC locality 46186 (sample 119NBd) at station 119NB-61) (=101NB-56) on west bank of Athabasca River, 0.3 km below mouth of Pierre River, Calumet Member, unit 3, 7.6 m above river level, estimated at 12.2 m above base of member.

GSC locality 46001 (sample 19NBb) at station 19NB-61 on north bank of Clearwater River, slightly above mouth of Cottonwood Creek, Calumet Member, unit 3, 3.8 m above river level, estimated at 17.9 m above base of member.

Strophodonta (Strophodonta) engstromi n. sp.
Plate 5, figures 19 - 38; Plate 6, figure 1

1868 *Strophomena (Strophodonta) demissa* Conrad; Meek, p. 87, Pl. 13, figs. 6a - 6c

1956 *Strophodonta halli* Cleland; Warren and Stelck, Pl. 13, fig. 19

Material. Represented by fairly numerous specimens.

Dimensions.

	GSC No.						*Strophodonta halli* Cleland; Stainbrook, 1938, p. 263.	
	Paratype 58709	Paratype 58710	Paratype 58711	Paratype 58712	Holotype 58713	Paratype 58714		
				(mm)				
GSC locality	46137	45999	45999	46137	29896	29224		
Length of pv (Lpv)	8.0	15.7	26.3	21.9	30.5	–	29.3	26.2
Length of bv (Lbv)	–	13.9	21.8	20.2	27.9	–		
Width (W)	12.0	21.0	28.3	33.0	37.7	+23.0	40.9	35.1
Depth of shell (D)	ca. 4.5	6.2	10.6	ca. 6.6	8.2	–	9.1	9.6
Ratio W/Lpv	1.50	1.34	1.16	1.53	1.24	–	1.40	1.43
Costae per 5 mm, 10 mm from beak	pv – bv –	pv 7 bv 6	pv 5.5 bv 6.5	pv 5 bv –	pv 6 bv 7	pv – bv –		
Costae per 5 mm, 20 mm from beak	pv – bv –	pv – bv –	pv 5 bv 5	pv 5 bv –	pv 5.5 bv 5.5	pv – bv –		

Description. Shell attains medium to large size, commonly semielliptical in outline, wider than long, commonly widest along the hinge line, cardinal extremities generally auriculate, relatively thick lateral profile.

Pedicle valve moderately convex, greatest elevation commonly at midlength, rarely at about two-thirds length from beak; umbo slightly to moderatly convex; beak small, slightly incurved and extending slightly beyond the hinge line; interarea low, highest beneath the beak, gradually diminishing in height laterally, slightly to moderately curved, anacline. The pedicle interarea of some specimens show fine, closely spaced transverse and longitudinal markings. One specimen, holotype 58713, shows a slightly raised, triangular shaped area beneath the beak.

Brachial valve moderately concave, flattening posterolaterally toward the cardinal extremities; an ill-defined median depression extends from the beak to the front of the valve in some specimens; beak very small, inconspicuous; interarea very low, almost flat, fairly uniform in height throughout most of width of valve, hypercline.

Surface ornamented with radiating, uneven, relatively coarse costae that increase in number anteriorly by bifurcation and intercalation. The crests of the costae are generally angular, but some are rounded. Troughs separating costae vary in width from less than to greater than that of the costae. Costae originating over the umbo area are conspicuously coarser and more closely spaced than those originating posterolaterally of this area. Concentration of costae average 6.1 per 5 mm of arc at 10 mm from the beak, and at 20 mm from beak average 5.2 per 5 mm of arc. Concentric growth lines generally coarse and irregularly spaced, tending to be more crowded toward the anterolateral margins.

Part of the interior of a pedicle valve can be seen on paratype 58714 (Pl. 6, fig. 1) showing part of the muscle impressions. The adductor muscle field is elliptical in outline and divided medianly by a shallow groove and divided obliquely into posterior and anterior adductor fields. A raised spindle-shaped area along the midline is present between the anterior end of the anterior adductor fields. The posterior adductor impressions are slightly wider and much less elevated than the anterior pair. The pair of diductor scars are subflabellate, radially fluted, and extend anterolaterally from each side of the anterior adductor scars to less than midlength of valve. The inner surface of the valve outside of the muscle fields is marked by tiny closely spaced pustules.

Comparison. ***Strophodonta (Strophodonta) engstromi*** n. sp. is closely comparable to ***Strophеodonta demissa*** (Conrad) as described by Branson (1922, p. 77 - 79, Pl. 11, figs. 3, 8, Pl. 14, figs. 1 - 8) from the Mineola Limestone, Callaway Limestone and Snyder Creek Shale of Missouri; and to ***Strophеodonta halli*** Cleland as described by Stainbrook (1938, p. 243 - 244, Pl. 35, figs. 1 - 3) from the ***"Atrypa" bellula*** Zone of the lower Rapid Member of Cedar Valley Limestone of Iowa. ***Strophodonta (S.) engstromi*** n. sp. is distinguished from ***S. demissa*** (Conrad) from Missouri by its thicker lateral profile, coarser costae, and by its more inflated pedicle umbo. From ***S. halli*** Cleland it is distinguished by its less extended cardinal extremities, its thicker lateral profile, and by its more inflated pedicle umbo which projects a greater distance beyond the hinge line.

Relatively narrow, semielliptical forms of ***Strophodonta (Strophodonta) engstromi*** n. sp., such as paratype 58711, with thick lateral profile and relatively coarse costae bear some resemblance to ***Strophodonta heteromya*** Imbrie (1959, p. 384, Pl. 58, figs. 1 - 6) from the uppermost Petoskey Formation of Michigan. ***S. (S.) engstromi*** is distinguished from the Michigan form by its more variable shape outline including relatively broad forms with slightly extended hinge lines and by its more widely spaced coarse costae.

Occurrence. The specimen described and illustrated by Meek (1868, p. 87, 88, Pl. 13, figs. 6a - 6c) as ***Strophomena (Strophodonta) demissa*** Conrad was collected from the Clearwater River from beds considered to be equivalent to the Devonian Hamilton Group of New York.

Concerning the beds containing ***Stropheodonta demissa*** (Conrad) in Missouri, Schumacher (1976, p. 160 - 163) considered the Mineola and Callaway as lithofacies within most of the upper part of the Cedar Valley Formation. As such (op. cit., fig. 1 and table 1), the range, in terms of conodont zones, may extend from the ***Polygnathus varcus*** Zone (undivided) to the Upper ***Polygnathus dengleri*** Subzone. Schumacher (1976, p. 160, fig. 1) as indicated previously, collated the Snyder Creek Shale of Missouri with the Lowermost (=Upper ***Polygnathus dengleri*** Subzone) to Middle ***Polygnathus asymmetricus*** Zones.

Stropheodonta halli Cleland was recorded by Warren and Stelck (1956, explanation of Pl. 13) from the ***Eleutherokomma hamiltoni*** Fauna of the Waterways Formation on Athabasca River, Alberta. They earlier (Warren and Stelck, 1950, p. 70 - 71) referred to this fauna as the ***Eleutherokomma hamiltoni*** Zone in the upper Waterways Formation occurring in beds above the ***"Spirifer" allani*** Zone and below beds of the ***Eleutherokomma leducensis*** Zone.

Strophodonta heteromya Imbrie (1959, p. 385) was recorded from locality 7c in the uppermost Petoskey Formation of the Traverse Bay area of Michigan. These beds appear to contain equivalents of the Thunder Bay and Squaw Bay Limestones of the Thunder Bay area of Michigan (Cooper et al., 1942, p. 1776 - 1777; Bultynck, 1976, p. 122 - 123, fig. 2). The most recent conodont dating of the Squaw Bay Limestone by Bultynck (1976) is given under a discussion of ***Schizophoria lata*** Stainbrook.

Strophodonta (Strophodonta) engstromi n. sp. appears to be confined to beds of the Calumet Member of the Waterways Formation outcropping along the upper Clearwater River and at one locality on the lower Athabasca River.

Derivation of name. The trivial name is after the late O.E. Engstrom who spent many winters trapping in the upper Clearwater River area.

Figured specimens. Paratypes 58709 and 58712 from GSC locality 46137; paratypes 58710 and 58711 from GSC locality 45999; holotype 58713 from GSC locality 29094; and paratype 58714 from GSC locality 29224.

Locality data. GSC locality 46137 (sample 20NBe) at station 20NB-61 on the north bank of Clearwater River, nearly opposite the mouth of Cottonwood Creek, Calumet Member, unit 7, 4.5 m above river level, estimated at 18.9 m above base of member.

GSC locality 45999 (sample 24NBh) at station 24NB-61 (=178NB-56) on the north bank of Clearwater River, 9.3 km below mouth of Cottonwood Creek, Calumet Member, unit 8, 5.9 m above river level, estimated at 24.9 m above base of member.

GSC locality 29094 (sample 107NBc) at station 178NB-56 (=24NB-61) on the north bank of Clearwater River, 9.3 km below mouth of Cottonwood Creek, Calumet Member, unit 2, 1.5 m above river level, estimated at 24.3 m above base of member.

GSC locality 29224 (sample 107NBd) at station 178NB-56 (=24NB-61) on the north bank of Clearwater River, 9.3 km below mouth of Cottonwood Creek, Calumet Member, unit 4, 3 m above river level, estimated at 23.2 m above base of member.

Strophodonta (Strophodonta) inflexa (Swallow)
Plate 6, figures 2 - 14

1860 *Strophodonta inflexa* Swallow, p. 637.
1897 *Stropheodonta navalis boonensis* Swallow; Schuchert, p. 425
1922 *Stropheodonta inflexa* Swallow; Branson, p. 81, Pl. 13, figs. 13 - 17
1944 *Stropheodonta inflexa* Swallow; Branson, Pl. 22, figs. 13 - 17

Material. Represented by few specimens.

Dimensions.

	GSC No.		
	58706	58707	58708
		(mm)	
GSC locality	46169	45983	45999
Length of pv (Lpv)	18.8	23.1	24.8
Length of bv (Lbv)	15.0	16.0	—
Width (W)	19.1	20.0	23.1
Depth of shell (D)	8.1	11.4	ca. 11.9
Ratio: W/Lpv	1.02	0.87	0.93
Costae per 5 mm, 10 mm from beak	pv 7 bv —	pv 6.5 bv 7	pv 7 bv —
Costae per 5 mm, 20 mm from beak	pv — bv —	pv 7 bv —	pv 6.5 bv —

Description. Shell of relatively small size at maturity, longitudinally subelliptical in outline, generally longer than wide, widest near or anterior of midlength, relatively thick, concavo-convex, thickest about midlength.

Pedicle valve very strongly convex, highest near the centre, regularly and moderately arched to the anterior margin, more abruptly arched posteriorly, fairly regularly arched transversely; cardinal extremities slightly extended in a few specimens; hinge line considerably less than maximum width of shell; umbo highly inflated, relatively narrow, considerably extended posteriorly beyond hinge line, strongly inturned; beak small; interarea low, highest opposite beak, curved, anacline, almost catacline towards apex in gerontic specimens.

Brachial valve moderately concave, regularly arched laterally and anteriorly strongly deflected towards cardinal margin, slightly depressed over umbo, interarea low, fairly even in height throughout most of width, nearly flat, hypercline; beak very small, inconspicuous.

Both valves ornamented by relatively coarse, radiating, uneven, angular to rounded costae that increase in number anteriorly by intercalation and less frequently by bifurcation. Intercostal troughs rounded, commonly of less width than costae. Concentration of costae is 6.5 to 7 per 5 mm of arc at 10 and 20 mm from beak. Concentric growth lines coarse, irregularly spaced, and more crowded towards anterior and lateral margins.

Part of the interior of the pedicle valve (Pl. 6, figs. 10 - 11) is evident in specimen 58708 which shows a longitudinally denticulated hinge margin which is medianly interrupted where the cardinal process of opposing valve projects into the pedicle valve.

Remarks. Of the variety of strophodontids represented in the Calumet Member of the Waterways Formation this form is easily distinguished by its relatively short hinge line, relatively narrow, longitudinal subelliptical profile, proportionately thick lateral profile, and by its relatively coarse uneven costae.

Occurrence. *Strophodonta (Strophodonta) inflexa* Swallow occurs typically in the Snyder Creek Shale of Montgomery and Callaway Counties, Missouri (Branson, 1922, p.). The conodont dating of the Snyder Creek Shale of Missouri by Schumacher (1976) is given under a discussion of *Strophodonta (Strophodonta) engstromi* n. sp.

In northeastern Alberta, *Strophodonta (S.) inflexa* is sparsely represented in the Calumet Member of the Waterways Formation outcropping along the upper Clearwater River and on the lower Athabasca River.

Figured specimens. GSC 58706 from GSC locality 46169; GSC 58707 from GSC locality 45983; and GSC 58708 from GSC locality 45999.

Locality data. GSC locality 46169 (sample 119NBa) at station 119NB-61 (=101NB-56) on the west bank of Athabasca River, 0.3 km below mouth of Pierre River, Calumet Member, unit 1, 2.0 m above river level, estimated at 6.5 m above base of member.

GSC locality 45983 (sample 24NBd) at station 24NB-61 (=178NB-56) on the north bank of Clearwater River, Calumet Member, unit 4, 3.1 m above river level, estimated at 22.1 m above base of member.

GSC locality 45999 (sample 24NBh) at station 24NB-61 (=178NB-56) on the north bank of Clearwater River, 9.3 km straight line distance below mouth of Cottonwood Creek, Calumet Member, unit 8, 6.0 m above river level, estimated at 24.9 m above base of member.

Strophodonta (Strophodonta) moberliensis n. sp.
Plate 6, figures 15, 17 - 18

1962 *Stropheodonta* sp.; McLaren, Norris and McGregor, Pl. 10, fig. 31 - 33

Material. Represented by few specimens.

Dimensions.

	GSC No.		
GSC No.	Paratype 58715	Holotype 58716	Paratype 58717
		(mm)	
GSC locality	46029	46029	46029
Length of pv (Lpv)	17.3	23.6	24.8
Length of bv (Lbv)	15.7	—	—
Width (W)	20.6	25.5	32.7
Depth (D)	7.4	ca. 11.4	ca. 11.0
Ratio: W/Lpv	1.19	1.08	1.31
Costae per 5 mm, 10 mm from beak	pv 6 bv 6	pv 5 bv —	pv 7.5 bv —
Costae per 5 mm, 20 mm from beak	pv — bv —	pv 6 bv —	pv — bv —

Description. Shell attains medium size at maturity, subquadrate to subsemicircular in outline, wider than long, greatest width along hinge line, cardinal extremities slightly extended, relatively thick concavo-convex lateral profile, greatest depth about midlength.

Pedicle valve strongly and regularly convex, highest near the centre, slightly auriculate cardinal extremities, umbo slightly to moderately inflated, beak small and slightly inturned; interarea low, nearly flat, of nearly the same height throughout width, orthocline.

Brachial valve moderately concave, slightly depressed in the umbonal region, beak inconspicuous, sharply upturned along and immediately anterior of the interarea, interarea flat, low, of uniform height throughout most of the width, hypercline.

Interiors of both valves not seen.

Costae of both valves moderately coarse, uneven, angular to round crested, crowded posteriorly but tending to be more widely spaced anteriorly, separated by rounded troughs of about equal width, costae increase in number anteriorly by intercalation and bifurcation. Concentration of costae averages 6.1 per 5 mm of arc at 10 mm from the beak. Superimposed on the costae and intercostal furrows are very fine, microscopic, closely spaced radiating markings. Concentric growth lines coarse, irregularly spaced, tending to be more crowded towards posterolateral margins.

Comparison. In shape outline *Strophodonta (Strophodonta) moberliensis* n. sp. is somewhat similar to *Stropheodonta callawayensis* Swallow as described and illustrated by Branson (1922, p. 75, 76, Pl. 13, figs. 1 - 5; 1944, Pl. 22, figs. 1 - 5) from the Snyder Creek Shale of Callaway County, Missouri. It differs from the Missouri form by attaining a smaller size at maturity, having considerably less extended cardinal extremities, and by having more even costae.

Strophodonta (Strophodonta) moberliensis n. sp. is also closely comparable in shape outline to *Stropheodonta littletonensis* Stainbrook (1938, p. 253, Pl. 34, figs. 10, 11, 14) from the *'Spinatrypa' bellula* Zone, lower Rapid Member, Cedar Valley Formation of Iowa. It is distinguished from the Iowa form by being smaller at maturity, having a shorter hinge line, a broader more inflated pedicle umbo, and by having a more subquadrate rather than a subsemielliptical outline.

Occurrence. *Strophodonta (Strophodonta) moberliensis* n. sp. is a rare constituent of the lower beds of the Moberly Member of the Waterways Formation outcropping along Athabasca River in northeastern Alberta.

Derivation of name. The trivial name is after Moberly Rapids located on Athabasca River just above Fort McMurray.

Figured specimens. Holotype 58716, and paratypes 58715 and 58717 from GSC locality 46029.

Locality data. GSC locality 46029 (sample 274NBg) at station 274NB-61 on the west bank of Athabasca River, 5.0 km below mouth of MacKay River, Moberly Member, unit 2, 3.4 m above river level, estimated at 1.7 m above base of member.

Family Stropheodontidae Caster, 1939

Subfamily Leptostrophiinae Caster, 1939

Genus *Nervostrophia* Caster, 1939, p. 79

Type Species: *Strophomena nervosa* Hall, 1843, p. 266; OD. (=*Sulcatostrophia* Caster, 1939, p. 81 (type, *Leptostrophia camerata* Fenton and Fenton, 1924, p. 96); *Pseudodouvillina* Stainbrook, 1945, p. 26 (type *P. euglyphea*))

Nervostrophia sp.
Plate 6, figures 16, 19 - 20

Material. Represented by very few specimens.

Dimensions.

	GSC No.		
	58718	58719	58720
		(mm)	
GSC locality	46000	29241	45999
Length of pv (Lpv)	17.7	17.9	—
Length of bv (Lbv)	—	—	8.4
Width (W)	2 x 15.4 = 30.8	30.1	12.4
Depth (D)	—	—	—
Ratio: W/Lpv	1.74	1.68	—

Description. Shell of small to medium size, weakly concavo-convex to nearly flat, subsemioval in outline with broadly curved antero-lateral margins, cardinal extremities auriculate, widest along the hinge-line, shell very thin and fragile and commonly broken at edges, showing a ragged or indented appearance.

Pedicle valve slightly convex, highest in the umbonal region, umbo slightly elevated; beak small and slightly projecting; interarea low, almost flat, decreasing gradually in height towards the extremities, interarea covered by fine, closely spaced longitudinal markings, apsacline; only a small part of pseudodeltidium present on specimen, presumed to have been very thin and strongly convex, covering an inverted V-shaped delthyrium.

Exterior of pedicle valve ornamented with numerous radial costae and costellae, both of which are irregular in size and extent, and increase by intercalation; costae are narrow, erect, discontinuous, highly variable in width, but generally much coarser towards the anterior and lateral margins; costellae are very fine, closely spaced, sharp crested, irregular, 3 to 8 occurring between the costae; concentric markings very fine, closely spaced, slightly finer than costellae, crossing both costae and costellae, producing a fine reticulate pattern on the shell; weak rugae evident on posterolateral sectors of shell surface.

No specimens show exterior of brachial valve.

Interior of pedicle valve showing a cardinal shelf with longitudinal denticulations that terminate about one-half the distance to the cardinal extremities; enclosing the muscle area posteriorly are two strong, narrow paradental ridges that are directed anterolaterally; ventral process partly filling delthyrial cavity on each side of which are apical indentations for reception of the cardinal process lobes. It extends anteriorly along the midline to edge of muscle area as a faint narrow ridge; muscle areas are flabellate and not well defined. Remainder of valve interior marked by fine closely spaced tuberculate markings, and vague irregular, radial, branching vascular markings; tuberculate markings tend to be coarser posterolaterally.

Interior of brachial valve with bilobed cardinal process directed dorso-posteriorly; thick, short socket plates parallel to the sides of, and abutting the cardinal process lobes; notothyrial platform low, muscle-bounding ridges slightly divergent, relatively high posteriorly; adductor scars on low platform of secondary shell deposit covering median ridge; posterolateral areas of valve interior covered with tuberculate markings; the coarser costae are impressed on the interior of the valve; hinge platform low, diminishing in height laterally, longitudinally denticulated.

Remarks. The material at hand is insufficient for a detailed comparison with other forms. The material does indicate, however, that the form from the Waterways

Formation is a low convexity, non-sulcate nervostrophiid, but the presence or absence of a median fold on the pseudodeltidium cannot be determined (see discussion by Williams, 1953, p. 42).

Occurrence. A *Nervostrophia* sp. was illustrated by Norris (in Norris and Uyeno, 1981) from beds of the Waterways Formation outcropping on the upper Birch River in northeastern Alberta which were correlated with the upper Calumet and lower Christina members of the Athabasca-Clearwater rivers area. The fossil assemblage from the Birch River beds was referred to as the *Ladogioides asmenista-Eleutherokomma jasperensis* Fauna and collated with the conodont Lower *Polygnathus asymmetricus* Zone.

An indeterminate species of *Nervostrophia* was recorded by Crickmay (1966, p. 19 - 20) from beds of the Christina Member of the Waterways Formation between 402.3 and 429.8 m depths in the type Bear Biltmore No. 1 well. The fauna of this interval (27.4 m thick) was assigned by Crickmay (1966, p. 20) to the lower part of the *Eleutherokomma jasperensis* Zone.

Nervostrophia sp. is a rare constituent of the Calumet and Christina Members of the Waterways Formation of northeastern Alberta, but appears to be slightly more numerous in the Calumet Member.

Figured specimens. GSC 58718 from GSC locality 46000, GSC 58719 from GSC locality 29241, and GSC 58720 from GSC locality 45999.

Locality data. GSC locality 46000 (sample 25NBc) at station 25NB-61 (=181NB-56) on the south bank of Clearwater River, 12.2 km above mouth of Christina River, Calumet Member, unit 4, 2.3 m above river level, estimated at 28.2 m above base of member.

GSC locality 29241 (sample 313NBa) at station 102NB-56 (=118NB-61) on the west bank of Athabasca River, 1.3 km below mouth of Pierre River, Calumet Member, unit -d, 4.6 m above river level, estimated at 10.8 m above base of member.

GSC locality 45999 (sample 24NBh) at station 24NB-61 (=178NB-56) on the north bank of Clearwater River, 9.3 km below mouth of Cottonwood Creek, Calumet Member, unit 8, 5.9 m above river level, estimated at 24.9 m above base of member.

Superfamily Strophalosiacea Schuchert, 1913

Family Strophalosiidae Schuchert, 1913

Subfamily Strophalosiinae Schuchert, 1913

Genus *Eostrophalosia* Stainbrook, 1943, p. 58

Type species: *Strophalosia rockfordensis* Hall and Clarke, 1893, p. 316; OD

Eostrophalosia pedderi Crickmay
Plate 6, figures 21 - 32

1956 *Productella* cf. *belanskii* Stainbrook; Warren and Stelck, Pl. 11, figs. 4 - 7

1963 *Eostrophalosia pedderi* Crickmay, p. 17, Pl. 5, figs. 10 - 15; Pl. 12, figs. 6 - 12

Material. Moderately abundant in the lower argillaceous part of the Moberly Member of the Waterways Formation outcropping on the Athabasca River in northeastern Alberta.

Dimensions.

	GSC No.						
	58703	58704	58705	58706	58707	58708	58709
	(mm)						
GSC locality	46113	46113	29176	46275	46022	46096	46052
Length of pv (Lpv)	19.7	ca.20.3	ca.25	16.2	—	—	—
Length of bv (Lbv)	—	—	—	13.6	12.6	ca.17.1	15.8
Width (W)	21.1	ca.20	25.6	18.0	ca.14.2	ca.19.3	21.2
Depth (D)	9.8	9.1	10.5	—	—	—	—
Ratio: W/Lpv	1.07	0.99	1.02	1 1	—	—	—

Description. Shell of medium size for the genus, semicircular to subcircular, concavo-convex, shell generally slightly wider than long, hinge line shorter than greatest width.

Pedicle valve moderately to strongly convex, highest a one-quarter to one-third length from umbo, posteriorly recurved beneath the beak, flattened at the cardinal angles; umbo strongly developed and extended beyond the hinge line; beak small and incurving, some specimens truncated by a small cicatrice of attachment; interarea low, highest in apical area, decreasing gradually in height laterally toward the extremities, slightly incurved, anacline; delthyrium triangular shaped, open, through which cardinal process of opposite valve is visible.

Brachial valve weakly to moderately concave, concavity is less than the convexity of the opposite valve, depressed in the umbonal region, elevated and flattened around the lateral and anterior margins of the valve; interarea very low, decreasing in height laterally, hypercline; apical region with a small convexity marking position of cardinal process.

Exterior of pedicle valve marked by rough, irregular, concentric growth lamellae and numerous closely spaced spines; spine bases fairly evenly distributed over the whole surface, emanating from elongate oval to short radial ridges that generally become more pronounced anteriorly, producing a pseudocostate appearance on the shell. Spines where preserved are smooth, straight, hollow, recumbent, and in excess of 4 mm long; along the posterior margin of the valve they are semi-erect and directed posterolaterally.

Exterior of brachial valve marked by fine, irregular, concentric growth lines and closely spaced spine bases; spines are smaller than those on the pedicle valve, recumbent, long, slender and straight.

Interior of pedicle valve not seen.

Interior of brachial valve with bifid cardinal process extending beyond hinge line, directed posteroventrally, with the apophyses short, divergent, slender, and longitudinally grooved at the extremities; alveolus shallow and indistinct; medium septum begins immediately anterior of alveolus and extends along midline for about two-thirds length of valve; low lateral ridges are present on each side of the base of the cardinal process which form the sides of shallow indentions or sockets between the ridges and the cardinal margins; faint spatula-shaped muscle platforms are present on each side of the medium septum at its posterior end; remainder of valve marked by low irregular concentric wrinkles, on and between which are scattered small pustules, oblong in shape, radiating from the beak, and resembling insipient spines; a slightly raised rim, about 3 mm wide, extends along the lateral and anterior interior margins of the valve.

Comparison. Eostrophalosia pedderi appears to be closely similar to *Eostrophalosia callawayensis* (Swallow) as described and illustrated by Branson (1922, p. 85, 86, Pl. 11, figs. 10, 16, Pl. 15, figs. 10, 11, 13, 14; 1944, p. 148, 150, Pl. 23, figs. 18, 19) from the Snyder Creek Shale of Missouri.

The latter species attains a slightly larger size at maturity, with larger specimens conspicuously wider than long, and having more pronounced cardinal angles.

From *Eostrophalosia rockfordensis* (Hall and Clarke, 1893; in Muir-Wood and Cooper, 1960, p. 77 - 79, Pl. 7, figs. 1 - 6) which is the type species for the genus, from the Cerro Gordo Member of the Hackberry Formation of Iowa, *E. pedderi* is distinguished by its much larger size at maturity, more closely and more regularly spaced spine bases, more inflate pedicle valve, and less conspicuous pedicle and brachial interareas. The spines on the brachial valve of *E. rockfordensis* appear to be weakly developed as they are on some specimens of *E. pedderi*.

From *Eostrophalosia littletonensis* (Stainbrook, 1943, p. 38, 39, Pl. 7, figs. 32 - 37) from the *"Atrypa" waterlooensis* Zone, Rapid Member of the Cedar Valley Formation, *E. pedderi* can be distinguished by its much larger size and more closely spaced spines on the pedicle valve.

From *Eostrophalosia independensis* (Stainbrook, 1945, p. 38, 39, Pl. 3, figs. 43 - 47) from the Independence Shale of Iowa, *E. pedderi* is distinguished by its much larger size and less numerous and more widely spaced spines on the brachial valve.

Eostrophalosia pedderi Crickmay (1963) is distinguished from *Productella belanskii* Stainbrook (1943, p. 53, 54, Pl. 7, figs. 1 - 7) from the *"Atrypa" independensis* Zone in the lower part of the Solon Member of the Cedar Valley Formation by the following features. *E. pedderi* has interareas on both valves; it has smaller and more closely spaced spines present on the exteriors of both valves, and the pedicle umbo is considerably less inflated and less inturned towards the opposite valve. In contrast, *P. belanskii* has larger more evenly arranged spines on the pedicle valve, the exterior of the brachial valve appears to lack spines, the interareas of both valves are in close contact with one another forming a line of junction, and the pedicle umbo is highly inflated and strongly inturned beyond the opposite valve.

Occurrence. The specimens identified as *Productella* cf. *belanskii* Stainbrook by Warren and Stelck (1956, Pl. 11, figs. 4 - 7) as part of the *"Allanaria" allani* Fauna were recorded from the Waterways Formation at McMurray, Alberta. In an earlier publication, Warren and Stelck (1950, p. 71) recorded *Productella* cf. *belanskii* Stainbrook as occurring within their *"Spirifer" allani* Zone which within the Waterways Formation occurs above their *Lingula* cf. *spatulata* Zone and below their *Eleutherokomma hamiltoni* Zone.

Crickmay (1963, p. 18) recorded this species from beds of the Moberly Member of the Waterways Formation outcropping on the east bank of Athabasca River, 42 km downstream from McMurray, and also on Steepbank River 3.2 km upstream from the mouth. Associated fossils at the former locality comprise: *Lorangerella* sp. n., *Atrypa* spp., and *Eleutherokomma hamiltoni* Crickmay; and from the latter locality: *Atrypa* sp., *A. clarkei* Warren, *'Allanaria' allani* (Warren) and *Schizophoria* sp. indet.

The specimens of *Eostrophalosia pedderi* described in this report are from the same general area and approximately the same stratigraphic interval as those described by Crickmay (1963). It occurs most abundantly in argillaceous limestone and shale beds of the Waterways Formation.

Eostrophalosia pedderi Crickmay has been recorded by Raasch (in Maurin and Raasch, 1972, Pl. 3) from their Assemblage 5 (sample 545) in the uppermost part of the Flume Formation at Cecilia Lake, in east-central British Columbia.

Figured specimens. GSC 58743 and 58744 from GSC locality 46113; GSC 58745 from GSC locality 29176; GSC 58746 from GSC locality 46275; GSC 58747 from GSC locality 46022; GSC 58748 from GSC locality 46094; and GSC 58749 from GSC locality 46052.

Locality data. GSC locality 46113 (sample 345NBc) at station 345NB–61 on the south bank of Beaver River, 0.2 km from mouth of river, Moberly Member, unit 4, 5.5 m above river level, estimated at 24.1 m above base of member.

GSC locality 29176 (sample 245NBb) at station 69NB–56 on east bank of Athabasca River, 7.1 km above the mouth of Beaver River, Moberly Member, unit e, 5.8 m above river level, estimated at 22.7 m above base of member.

GSC locality 46275 (sample 57NBb) at station 56NB–61 on the west bank of Athabasca River, 1.1 km below mouth of Steepbank River, Moberly Member, estimated at 16.6 m above base of member.

GSC locality 46022 (sample 297NBa) at station 297NB–61 on the north bank of MacKay River, 14.8 km straight line distance from the mouth of river, Moberly Member, unit 1, 3.9 m above river level, estimated at 27.4 m above base of member.

GSC locality 46094 (sample 347NBa) at station 347NB–61 on the north bank of Beaver River, 0.6 km straight line distance from mouth of river, Moberly Member, unit 6, 5.1 m above river level, estimated at 20.8 m above base of member.

GSC locality 46052 (sample 345NBa) at station 345NB–61 on the south bank of Beaver River 0.3 km from mouth of river, Moberly Member, unit 2, 4.0 m above river level, estimated at 20.9 m above base of member.

Superfamily Productacea Gray, 1840

Family Leioproductidae Muir-Wood and Cooper, 1960

Subfamily Devonoproductinae Muir-Wood and Cooper, 1960

Genus *Devonoproductus* Stainbrook, 1943, p. 55

Type species: *Productella walcotti* Fenton and Fenton, 1924, p. 119 ((=*Productus dissimilis* Hall, 1858, p. 497, non Dekoninck, 1847, p. 255) (=*P. (Productella) hallana* Walcott, 1884, p. 130, partim); OD) (=*Striatopoproductus* Nalivkin, 1947, p. 75 (type, *Orthis sericea* Von Buch, 1838, p. 68)).

Devonoproductus catamorphus (Crickmay)
Plate 6, figures 33 - 35; Plate 7, figures 1 - 7

1956 *Productella* sp., Warren and Stelck, Pl. 13, fig. 30
1963 *Chonopectoides catamorphus* Crickmay, p. 23, Pl. 15, figs. 1 - 7

Material. Abundant locally in some beds in the lower part of the Moberly Member of the Waterways Formation outcropping on the lower Athabasca River.

Dimensions.

Description. Shell very small, productiform, plano-convex, approximately semicircular in outline, wider than long, greatest width commonly along hinge line, postero-lateral angles acute, cicatrice of attachment not evident.

Pedicle valve very gently to moderately convex, highest about midlength, arching regularly anteriorly and more strongly to beak, moderately arched transversely, surface concave towards posterolateral angles, which are slightly extended and acute in some specimens; umbo moderately developed, narrow, projecting very slightly beyond hinge line; beak very small, inconspicuous; interarea linear, little exposed.

Brachial valve flat to very slightly convex; postero-lateral extremities slightly extended in some specimens; umbo concave to flat, marked by a narrow longitudinal elevation in some specimens; beak very small, pointed, slightly extended beyond hinge line; interarea linear.

Exterior of pedicle valve marked by numerous, fine, closely spaced, irregular, interrupted radiating costellae; concentric growth lines irregularly spaced but most conspicuous toward antero-lateral margins; posterior margin bearing on each side three and rarely four fine long spines which are directed laterally; some specimens with a few irregularly scattered spines which are long, delicate, erect, and occur mainly near the lateral and anterior margins of the valve.

Exterior of brachial valve ornamented with conspicuous, rather evenly and widely spaced concentric lamellae, evident on each lamella are very fine, closely spaced radial costellae.

Interior of pedicle valve with a large, smooth visceral cavity, narrowly rounded toward the beak and broadly rounded antero-laterally, bounded by a flat, shelf-like margin postero-laterally and by a rounded shelf-like margin antero-laterally.

Interior of brachial valve with bifid cardinal process which projects posteriorly in plane of valve, each prong is posteriorly grooved; visceral area occupying most of interior of valve, which is emarginate anteriorly and bordered postero-laterally and laterally by curved ridges; a weakly developed median septum arises in front of base of cardinal process and extends forward to about two-thirds length of valve; interior of valve covered with concentric depressions that reflect the concentric lamellae on exterior of valve; irregular, radially elongate papillae occur between the concentric depressions, the papillae become elongate toward the antero-lateral margins of the valve.

Discussion. In erecting the genus *Chonopectoides*, Crickmay (1963, p. 23) distinguished it from the genus *Devonoproductus* Stainbrook (1943) by small size, lack of inflation of pedicle valve, and reduction of spines to a small number on hinge margin only. From *Chonetes* Fischer de Waldheim (1830), Crickmay (1963, p. 23) distinguished *Chonopectoides* by its *Devonoproductus*-like ornament. Of these distinguishing criteria, probably the most diagnostic is the presumed restriction of spines to the hinge margin only. In the present large collection, some of the larger specimens of the pedicle valve show fine widely spaced spines near and along the lateral and anterior margins of the valve but are otherwise indistinguishable from *Chonopectoides catamorphus* Crickmay (1963). The features displayed by *C. catamorphus* appear to be those of juvenile growth stages of *Devonoproductus* and for this reason the writer considers it to be a species of that genus.

Comparison. Devonoproductus catamorphus (Crickmay) is distinguished from *D. tertius* Crickmay by its much smaller size, and by the reduced number of spines along and near the lateral and anterior margins of the pedicle valve. In other features the two forms are very closely related.

Occurrence. Devonoproductus catamorphus is recorded by Crickmay (1963, p. 23) from the lowest beds of the Moberly Member of the Waterways Formation at 397.5 m in the Bear Biltmore No.1 well (7-11-87-17-W4W) and also at 649.2 m in the Bear Beaumont No.1 well (14-25-77-W4). This latter level appears also to be near the base of the Moberly Member of the Waterways Formation (see Belyea, 1952, fig. 3).

In this study, *Devonoproductus catamorphus* was recorded from scattered outcrops of the lower argillaceous part of the Moberly Member of the Waterways Formation outcropping on Beaver River, MacKay River, and along Athabasca River in the vicinity of Fort MacKay.

Figured specimens. GSC No. 58750, 58751, 58754, 58757, 58758 and 58759 from GSC locality 46043; and GSC No. 58752, 58753, 59755, and 58756 from GSC locality 46172.

Locality data. GSC locality 46043 (sample 309NBb) at station 309NB-61 on northwest bank of MacKay River, 12.6 km straight line distance from mouth of river, Moberly Member, loose in unit 6, 1.2 m above river level, estimated at 13.7 m above base of member.

GSC locality 46172 (sample 273NBb) at station 273NB-61 on west bank of Athabasca River, 5.8 km below mouth of MacKay River, Moberly Member, unit 4, 5.6 m above river level, estimated at 6.1 m above base of member.

Devonoproductus reticulocostus n. sp.
Plate 7, figures 8 - 18

1868 *Productus dissimilis* Hall?; Meek, p. 19, Pl. 13, figs. 3a - 3c

Material. Represented by a few specimens from scattered horizons and localities of the Calumet, Christina and Moberly members of the Waterways Formation.

Dimensions.

	GSC No.						
	Holotype 58760	Paratype 58761	Paratype 58762	Paratype 58763	Paratype 58764	Paratype 58765	Paratype 58766
	(mm)						
GSC locality	46133	46133	46133	46133	46133	45976	29089
Length of pv (Lpv)	+11.3	—	ca.11.3	ca.14.6	—	16.9	—
Length of lv (Llv)	—	8.8	—	—	7.3	—	10.5
Width (W)	ca.13.5	12.0	ca.12.3	ca.18	8.5	+14.3	ca.12.9
Depth (D)	ca.6.1	—	ca.6.2	ca.7.2	—	ca.7.3	—
Ratio W/Lpv	1.19	—	1.08	1.23	—	0.85	—
Ratio W/Wpi	—	1.03	1.09	—	1.16	—	1.18

Description. Shell attains medium size, concavo-convex, generally wider than long, broadest at about one-third length from beak, hinge line slightly less than breadth, suboval to subsemicircular in outline.

Pedicle valve strongly convex, highest at about one-third midlength, moderately arched to front, and much more strongly to beak, strongly arched transversely, concave posterolaterally, cardinal extremities rounded; umbo relatively broad, projecting beyond hinge line; beak small, incurved; interarea linear, nature of delthyrium not evident in specimens at hand.

Brachial valve shallowly concave, deepest at about one-third length from beak, surface abruptly elevated adjacent to interarea; umbonal region conspicuously depressed; interarea very low, almost linear; beak very small, elevated.

Exterior of pedicle valve marked by numerous, closely spaced, highly irregular, interrupted, fine radiating costae; concentric growth markings irregularly spaced, interrupted in places. The interrupted growth lamellae together with the

costae produce an irregular reticulate pattern particularly in the posterior part of the valve. Spine bases small, longitudinally elongate, hollow, widely scattered; spines where partly preserved are slender, erect, and are most abundant anterolaterally and along cardinal margins.

Exterior of brachial valve marked by relatively coarse concentric lamellae on which are very fine closely spaced growth lines; traces of very fine radial costellae visible on some lamellae.

Interior of pedicle valve not seen.

Interior of brachial valve with stout, bilobate cardinal process projecting posterolaterally in plane of valve beyond hinge line; muscle impressions not evident; strong concentric markings impressed on interior of valve reflecting the exterior concentric lamellae, and these appear to surround the visceral area laterally and anteriorly. Irregular, radially elongate closely spaced papillae cover the concentric markings; a thin, low median septum arises well beyond the base of the cardinal process and extends to about midlength of valve.

Comparison. *Devonoproductus reticulocostus* n. sp. is distinguished from *Devonoproductus tertius* Crickmay by its pronounced reticulate ornamentation on the exterior of the pedicle valve, and by the concentric markings and concentric arrangement of papillae on the interior of the brachial valve.

Occurrence. *Devonoproductus reticulocostus* n. sp. occurs sparingly in the Calumet and Christina members and more abundantly in the Moberly Member of the Waterways Formation.

Derivation of name. The trivial name is in allusion to the reticulate ornamentation on the exterior of the pedicle valve of this form.

Figured specimens. Holotype 58760 and paratypes 58761, 58762, 58763 and 58764 from GSC locality 46133; paratype 58765 from GSC locality 45976; and paratype 58766 from GSC locality 29089.

Locality data. GSC locality 46133 (sample 355NBc) at station 355NB-61 on the east bank of Athabasca River, opposite the mouth of Beaver River, Moberly Member, top of unit 6, 7.0 m above river level, estimated at 18.6 m above base of member.

GSC locality 45976 (sample 268NBd) at station 268NB-61 on the east bank of Athabasca River, Moberly Member, 8.4 km downstream from mouth of MacKay River, Moberly Member, unit 7, 11.4 m above base of member.

GSC locality 29089 (sample 107NBf) at station 181NB-56 on the south bank of Clearwater River, 12.2 km above the junction with the Christina River, Calumet Member, unit 1, 0.9 m above river level, estimated at 28.5 m above base of member.

Devonoproductus tertius Crickmay
Plate 7, figures 19 - 30

1956 *Productella* sp., Warren and Stelck, Pl. 13, figs. 20 - 23

1963 *Devonoproductus tertius* Crickmay, p. 26, Pl. 5, figs. 25 - 30, Pl. 14, figs. 23 - 26

Material. Moderately abundant in some beds in the lower part of the Moberly Member of the Waterways Formation of northeastern Alberta.

Dimensions.

	58757	58758	58759	58770	GSC No. 58771 (mm)	58772	58773	58774	Measurements similar Crickmay 1963, p. 27
GSC locality	46133	46133	46133	46133	46133	46133	46133	46133	
Length of pv (Lpv)	6.3	ca.6.3	–	–	–	–	–	–	5.5
Length of bv (Lbv)	–	–	3.8	5.2	11.6	9.8	8.3	12.3	
Width (W)	7.1	ca.7.9	6.3	6.9	13.4	9.5	9.3	11.9	9
Depth (D)	–	–	–	–	–	–	–	–	3
Ratios W/Lpv	1.48	0.99	–	–	–	–	–	–	1.27
Ratios W/Lbv	–	–	1.31	1.29	1.18	1.88	1.16	1.23	–

Description. Shell attains a medium size for the genus, productiform, concavo-convex, roughly semicircular in outline; hinge line slightly greater to slightly less than width of shell, cardinal angles acute; cicatrice of attachment not evident.

Pedicle valve of moderate convexity, highest about midlength, strongly arched from beak to front, especially in posterior region, strongly arched transversely in the central part, flanks gently arched; cardinal extremities depressed and slightly extended in some specimens; umbo prominent and high, extended beyond the hinge line but no evidence of attachment; beak small, inturned; interarea not visible on any of the specimens.

Brachial valve nearly flat in young stages and weakly concave anteriorly in adult stages; umbo with a slightly raised longitudinal median ridge which disappears anteriorly within a millimetre length; beak very small; interarea not seen.

Interior of pedicle valve seen only in isolated fragments; a deep visceral cavity is sharply set off from the smaller remaining part of valve, it is semi-oval in shape and broadest anteriorly.

Interior of brachial valve well represented by disarticulated valves; cardinal process is bifid, U-shaped, slightly raised, and projects posteriorly in plane of valve, each prong is longitudinally grooved posteriorly; visceral area occupying most of the interior of valve, strongly emarginate at the front and bordered posterolaterally by broad, shallow, slightly curved depressions which originate near the base of the cardinal process, widens laterally and gradually disappears at about one-third length of valve; a thin median septum arises in front of the base of the cardinal process and extends forward for about two-thirds length of valve; in some specimens a linear shallow groove occurs on each side of the anterior third of the median septum; most of remaining interior of valve covered with oval shaped papillae (endospines?) with marked concentric and vague radial arrangement, which are slightly larger towards the lateral and anterior margins of valve.

Exterior of pedicle valve ornamented with very fine, irregular, discontinuous, obscure, nodose, radiating costellae of irregular width; costellae interruped by irregularly spaced concentric growth lines; spines small, long, slender, erect, widely and irregularly spaced, most abundant near anterior and lateral margins, and along hinge line and extremities, three or four spines occurring along and near hinge line on each side of the beak and directed posterolaterally; spine bases nearly circular in outline.

Exterior of brachial valve ornamented with conspicuous concentric lamellae on which can be seen exceedingly fine concentric growth lines; some larger mature specimens show fine, weakly developed radial costellae on the lamellae.

Comparison. According to Crickmay (1963, p. 25), the distinguishing features of *Devonoproductus tertius* Crickmay are its broad outline and very gentle convexity. His comparison was made with *Devonoproductus primus* from the Middle Devonian Pine Point Formation of the Dawson Landing area on the south side of Great Slave Lake; with *Devonoproductus minimus* from the top of the Middle Devonian Presqu'ile Formation, on the east side of Sulphur

Point, south shore of Great Slave Lake; and with *Devonoproductus secundus* from the Upper Devonian topmost bed of the Flume Formation on the mountain located southeast of Cecilia Lake, British Columbia at latitude 53°36'N.

From *Devonoproductus catamorphus* (Crickmay, 1963, p. 23, 24, Pl. 15, figs. 1 - 7), *D. tertius* is distinguished by its much larger size at maturity, and by the presence of widely spaced, long, slender, erect spines near the anterior and lateral margins of the pedicle valve.

Occurrence. The type specimens of *Devonoproductus tertius* were recorded by Crickmay (1963, p. 27) from the lower part of the Beaverhill Lake Formation in the Imperial Morse River 14-31-63-8W5 well at a depth of 2353 m, and ranges from 2338.5 to 2356 m. This interval was assigned by Crickmay (1963) to the "*Stropheodonta costata*" Zone which would suggest that it is approximately equivalent to the Calumet Member of the Waterways Formation of northeastern Alberta.

The closely related species, *Devonoproductus secundus* Crickmay, has been recorded by Raasch (in Maurin and Raasch, 1972, Pl. 3) from the upper half of their Assemblage 4, in the upper Flume Formation at Cecilia Lake, east-central British Columbia.

In the outcrop belt of the Waterways Formation of northeastern Alberta, *Devonoproductus tertius* occurs abundantly in some scattered beds within the lower part of the Moberly Member.

Figured specimens. GSC 58767, 58769 and 58770 from GSC locality 46102; GSC 58768 from GSC locality 46136; and GSC 58771, 58772, 58773, and 58774 from GSC locality 46078.

Locality data. GSC locality 46102 (sample 347NBb) at station 347NB-61 on the north bank of Beaver River, 0.8 km straight line distance above the mouth of the river, Moberly Member, unit 3, 2.2 m above river level, estimated at 17.2 m above base of the member.

GSC locality 46156 (sample 35NBa) at station 35NB-61 on the north bank of Clearwater River, 12.9 km below the junction with the Christina River, Moberly Member, unit 2, 3.9 m above river level, estimated at 12.9 m above base of member.

GSC locality 46078 (sample 273NBa) at station 273NB-61 on the west bank of Athabasca River, 5.8 km below mouth of MacKay River, Moberly Member, unit 3, 3.6 m above river level, estimated at 4.3 m above base of member.

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PLATES 1 to 7

PLATE 1

Figures 1 - 16. *Schizophoria allani* Warren

1 - 4 Pedicle (1), lateral (2), anterior (3) and posterior (4) views of a relatively thick small adult individual, x1, GSC 58739, GSC locality 29266.

5 - 7 Lateral (5), posterior (6) and pedicle (7) views of an elongate small adult individual, x1, GSC 58740, GSC locality 29266.

8 - 11 Brachial (8), pedicle (9), anterior (10) and lateral (11) views of a relatively broad adult individual, x1, GSC 59741, GSC locality 29075.

12 - 16 Brachial (12), lateral (13), pedicle (14), posterior (15) and anterior (16) views of a relatively large gerontic individual, x1, GSC 58742, GSC locality 29266.

Figures 17 - 16. *Schizophoria athabaskensis* Warren

17 - 23 Lateral (17 and 18), x2 and x1, anterior (19), x1, brachial (20 and 21), x1 and x2, pedicle (22 and 23), x1 and x2, views of a young relatively coarsely costate individual, GSC 58732, GSC locality 46183.

24 - 26 Pedicle (24), anterior (25) and posterior (26) views of a young adult individual, x1, GSC 58733, GSC locality 45979. See also Plate 2, figure 1.

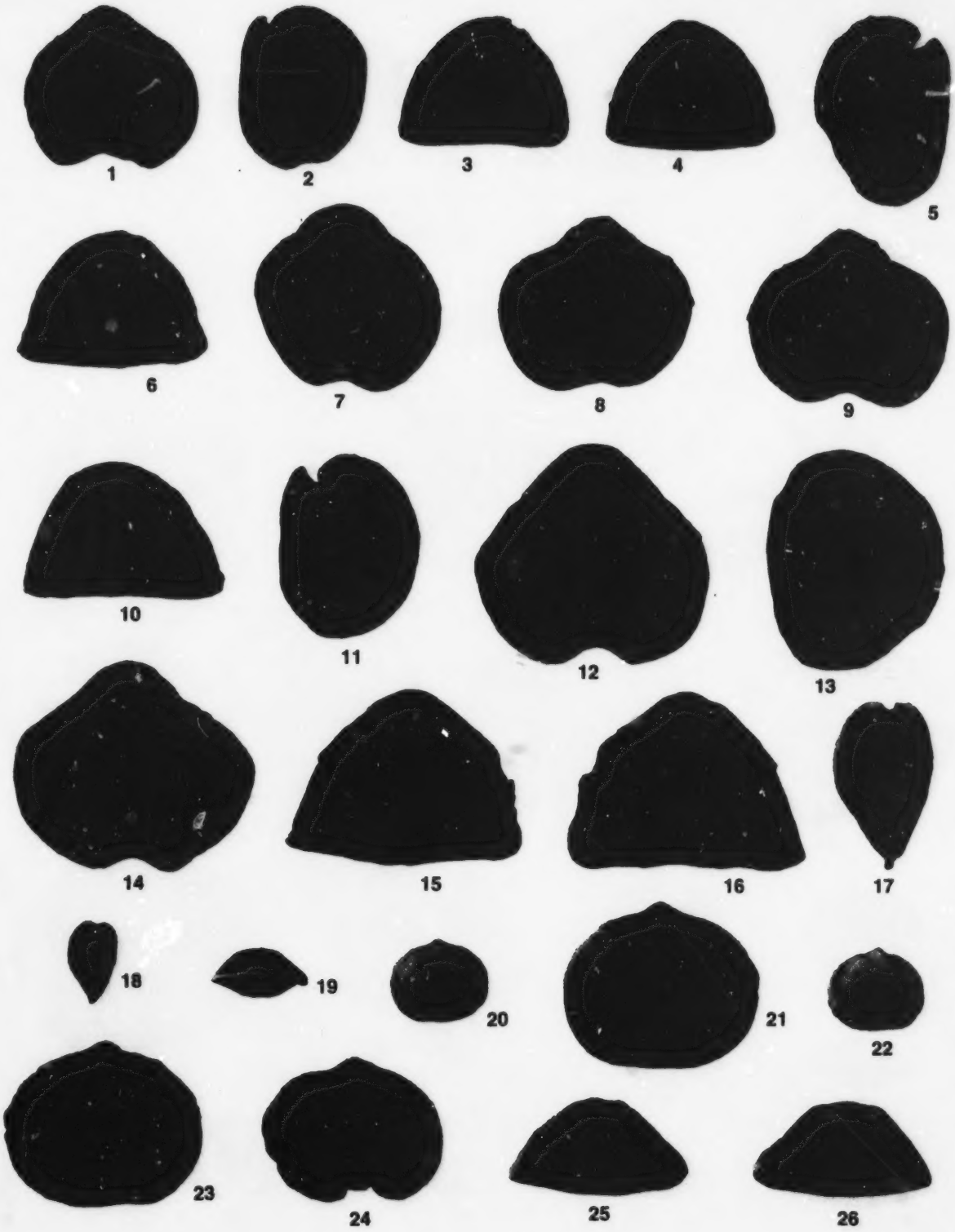
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PLATE 2

Figures 1 - 17. *Schizophoria athabaskensis* Warren

1 Lateral view of a young adult individual, x1, GSC 58733, GSC locality 45979. See also Plate 1, figures 24 - 26, for other views of this specimen.

2 - 5 Brachial (2), pedicle (3), lateral (4) and anterior (5) views of a relatively thick mature adult individual, x1, GSC 58734, GSC locality 29075.

6 - 10 Lateral (6), anterior (7), posterior (8), brachial (9) and pedicle (10) views of a relatively thin, wide, mature adult individual, x1, GSC 58735, GSC locality 45999.

11 - 15 Posterior (11), anterior (12), lateral (13), pedicle (14) and brachial (15) views of relatively thick gerontic individual, x1, GSC 58736, GSC locality 46170.

16 Interior view of pedicle valve of a gerontic individual, x1 GSC 58737, GSC locality 29239.

17 Interior view of an incomplete brachial valve of a young adult individual, x2, GSC 58738, GSC locality 29335.

Figures 18 - 26. *Schizophoria lata* Stainbrook

18 - 22 Brachial (18), pedicle (19), posterior (20), anterior (21) and lateral (22) views of a very young individual, x2, GSC 58724, GSC locality 46187.

23 - 25 Pedicle (23), anterior (24) and posterior (25) views of a thin, broad, young individual, x1, GSC 58725, GSC locality 46274.

26 Anterior view of a circular young individual, x1, GSC 58726, GSC locality 45981. See also Plate 3, figures 1 - 4, for other views of this specimen.

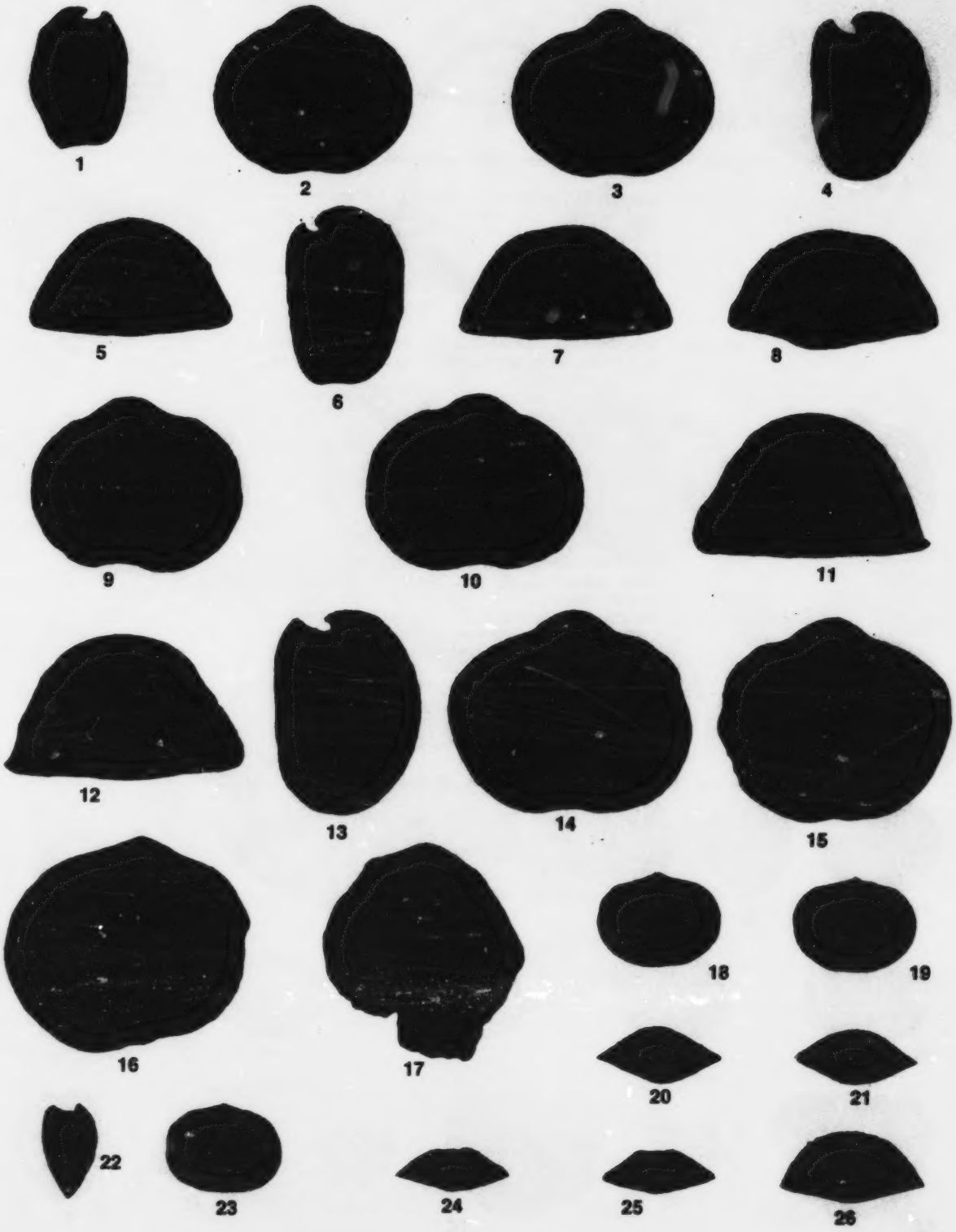
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PLATE 3

Figures 1 - 15. *Schizophoria lata* Stainbrook

1 - 4 Brachial (1), pedicle (2), posterior (3) and lateral (4) views of a circular young individual, x1, GSC 58726, GSC locality 45981. See also Plate 2, figure 27, for another view of this specimen.

5 - 9 Brachial (5), pedicle (6), posterior (7), lateral (8) and anterior (9) views of a thin, wide, young adult individual, x1, GSC 58727, GSC locality 46187.

10 - 12 Brachial (10), lateral (11) and pedicle (12) views of a thick, wide, adult individual, x1, GSC 58728, GSC locality 46170.

13, 14 Exterior (13) and interior (14) views of pedicle valve of a young adult individual, x1, GSC 58729, GSC locality 46187.

15 Pedicle view of a very large, thin adult individual, x1, GSC 58730, GSC locality 45982.

Figures 16 - 29. *Schizophoria warreni* n. sp.

16 - 10 Pedicle (16), lateral (17), brachial (18), posterior (19) and anterior (20) views of a circular young adult individual, xl, GSC paratype 58721, GSC locality 46195.

21 - 25 Pedicle (21), lateral (22), brachial (23), posterior (24) and anterior (25) views of a circular, mature adult individual, xl, GSC holotype 58722, GSC locality 46195.

26 - 29 Brachial (26), pedicle (27), lateral (28) and anterior (29) views of a rotund, mature adult individual, x1, GSC paratype 58723, GSC locality 46195.

Figures 30 - 33. *Strophodonta (Strophodonta) albertensis* n. sp.

30 - 33 Pedicle (30 and 31), x1 and x2, and brachial (32 and 33), x1 and x2, views of a young individual, GSC paratype 58683, GSC locality 46130. See also Plate 4, figures 1 - 13, for other illustrated specimens of this species.

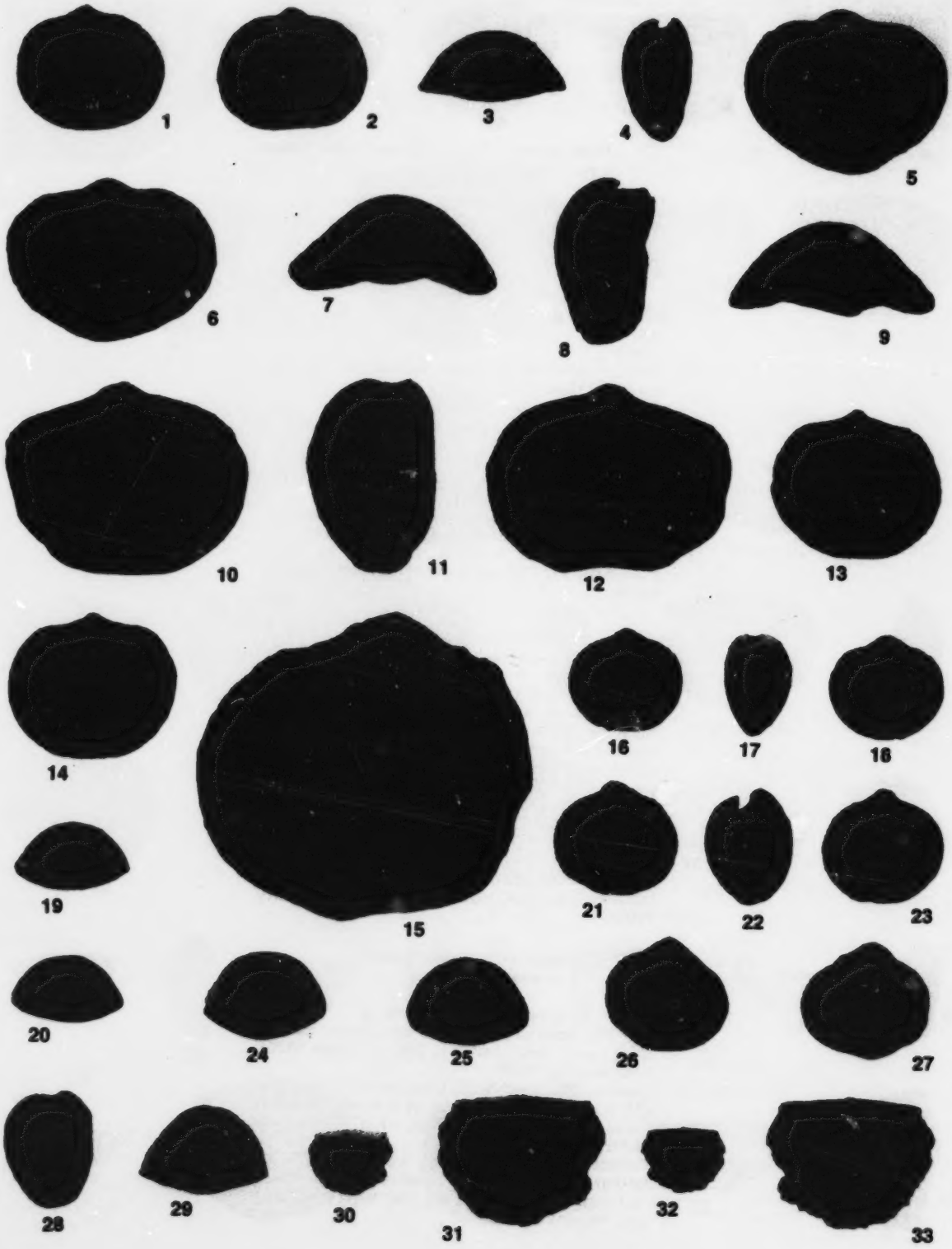
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PLATE 4

Figures 1 - 13. *Strophodonta (Strophodonta) albertensis* n. sp.

1, 2 Pedicle (1 and 2) views of a young individual, x2 and x1, GSC paratype 58684, GSC locality 45999.
3 Pedicle view of a young individual, x1, GSC paratype 58685, GSC locality 45999.
4 Pedicle view of a young adult individual, x1, GSC paratype 58686, GSC locality 45999.
5, 6 Brachial (5) and lateral (6) views of a young adult individual, x1, GSC paratype 58686, GSC locality 45999.
7 Pedicle view of an adult individual, x1, GSC paratype 58687, GSC locality 45999.
8 Pedicle view of a large, elongate, adult individual, x1, GSC paratype 58688, GSC locality 46130.
9 - 11 Pedicle (9), brachial (10) and lateral (11) views of a young adult individual, x1, GSC holotype 58689, GSC locality 46001.
12 Pedicle view of a large, thick, adult individual, x1, GSC paratype 58690, GSC locality 45999.
13 Interior view of brachial valve of an adult individual, x1, GSC paratype 58691, GSC locality 45999.

Figures 14 - 24. *Strophodonta (Strophodonta) calumetensis* n. sp.

14 - 16 Pedicle (14 and 15), x1 and x2, and lateral (16), x2, views of a broad, young individual, GSC paratype 58692, GSC locality 46001.
17 - 19 Pedicle (17 and 18), x1 and x2, and lateral (19), x1, views of a broad, young adult individual, GSC paratype 58693, GSC locality 46001.
20, 21 Pedicle (20) and lateral (21) views of a young adult individual, x1, GSC holotype 58694, GSC locality 46001.
22 - 24 Pedicle (22), posterior (23) and brachial (24) views of a relatively thick, narrow, adult individual, x1, GSC paratype 58695, GSC locality 46001.

Figures 25 - 38. *Strophodonta (Strophodonta) clearwaterensis* n. sp.

25 - 29 Pedicle (25), brachial (26), posterior (27), lateral (28) and anterior (29) views of a small, narrow, thick, adult individual, x1, GSC paratype 58701, GSC locality 46169.
30 - 34 Pedicle (30), brachial (31), posterior (32), lateral (33) and anterior (34) views of a small, relatively broad, thick, adult individual, x1, GSC paratype 58702, GSC locality 46169.
35 - 38 Pedicle (35), brachial (36), posterior (37) and lateral (38) views of a relatively large, thick, mature adult individual, x1, GSC holotype 58703, GSC locality 46130.

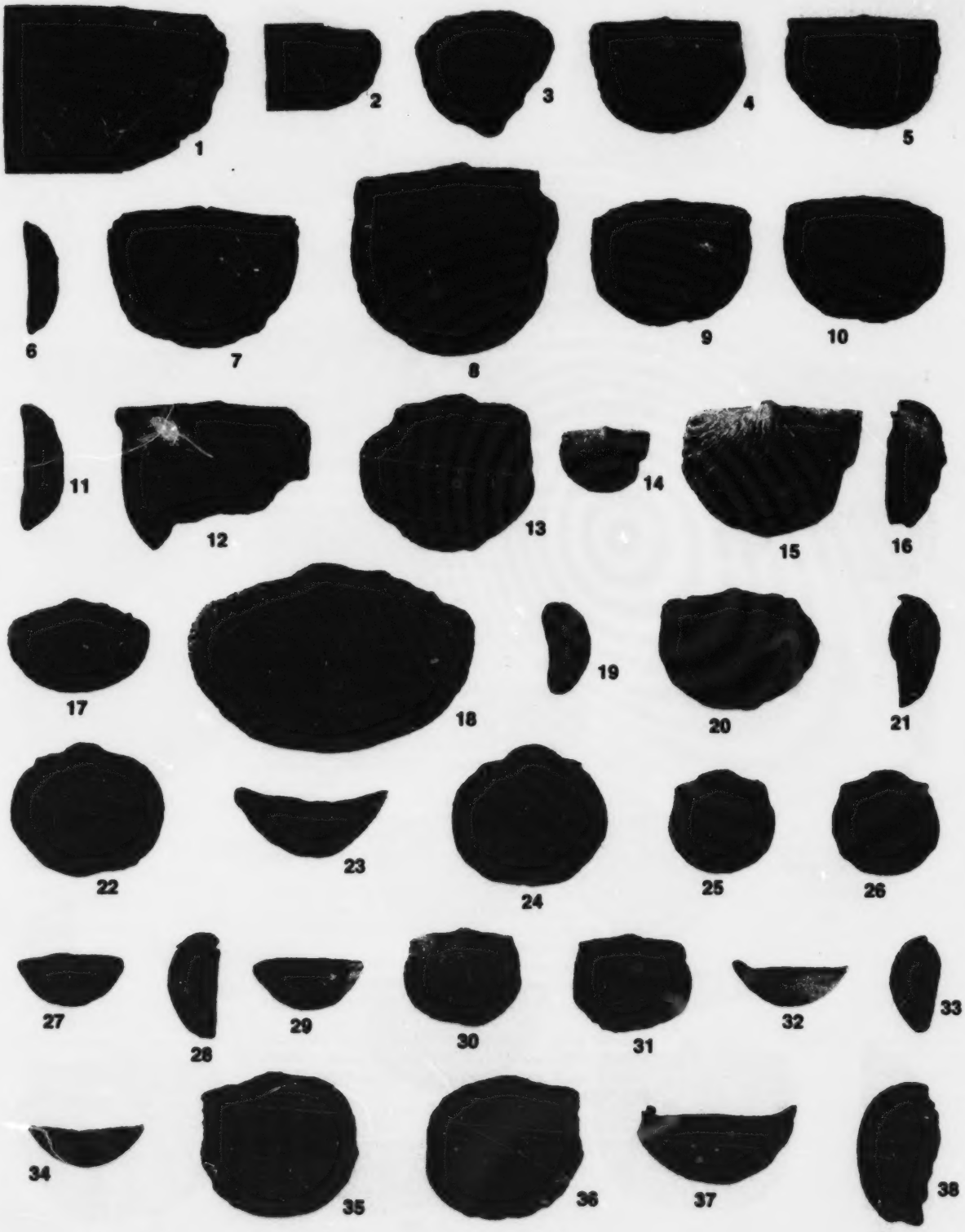
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PLATE 5

Figures 1 - 4. *Strophodonta (Strophodonta) clearwaterensis* n. sp.

1, 2 Interior views of a pedicle valve of a small, thick, adult individual, x1 and x2, GSC paratype 58704, GSC locality 46103.

3, 4 Interior views of a brachial valve of a small adult individual, x1 and x2, GSC paratype 58705, GSC locality 29239.

Figures 5 - 18. *Strophodonta (Strophodonta) dorsata* (Stainbrook)

5 - 8 Pedicle (5), lateral (6), posterior (7) and anterior (8) views of a young adult individual, x1, GSC 58696, GSC locality 46170.

9 - 12 Pedicle (9), posterior (10), lateral (11) and anterior (12) views, of a relatively thick mature adult individual, x1, GSC 58697, GSC locality 46005.

13 - 15 Pedicle (13), anterior (14) posterior (15) views of a relatively broad, large, adult individual, x1, GSC 58698, GSC locality 46005.

16 View of exterior of a brachial valve of an adult individual, x1, GSC 58699, GSC locality 46186.

17, 18 Views of exterior and interior of a brachial valve of an adult individual, x1, GSC 58700, GSC locality 46001.

Figures 19 - 38. *Strophodonta (Strophodonta) engstromi* n. sp.

19, 20 Pedicle views of a thick, very young individual, x1 and x2, GSC paratype 58709, GSC locality 46137.

21 - 27 Pedicle (21 and 22), x2 and x1, brachial (23 and 24), x1 and x2, lateral (25), posterior (26) and anterior (27) views of a transversely subelliptical young individual, x1, GSC paratype 58710, GSC locality 45999.

28 - 32 Pedicle (28), brachial (29), posterior (30), lateral (31), and anterior (32) views of a subcircular young adult individual, x1, GSC paratype 58711, GSC locality 45999.

33, 34 Pedicle (33) and posterior (34) views of a young adult individual with slightly extended cardinal angles, x1, GSC paratype 58712, GSC locality 46137.

35 - 38 Pedicle (35), posterior (36), brachial (37) and lateral (38) views of a semicircular, thick, mature adult individual, x1, GSC holotype 58713, GSC locality 29094.

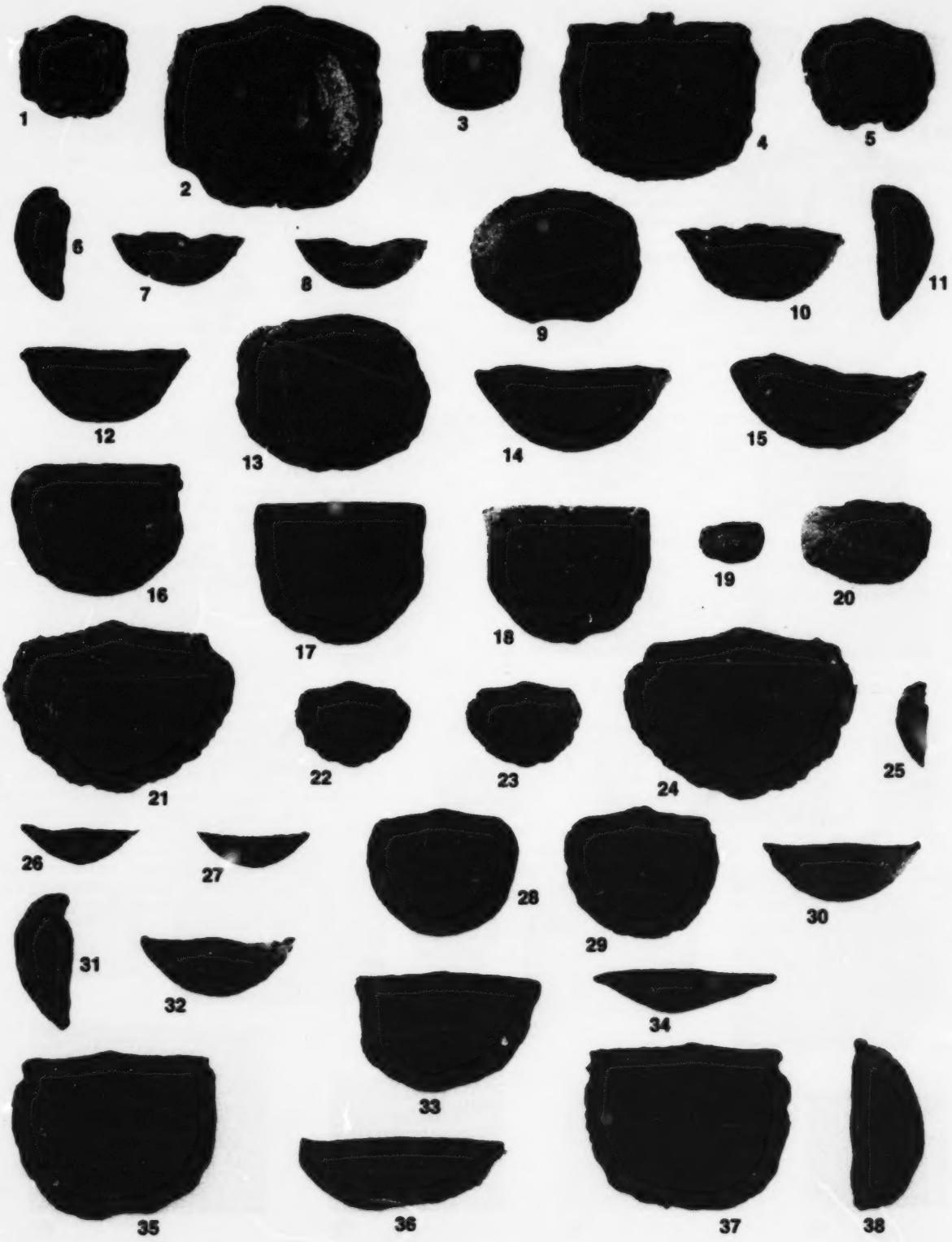
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PLATE 6

Figure 1. *Strophodonta (Strophodonta) engstromi* n. sp.

1 Interior view of an incomplete pedicle valve, x1, GSC paratype 58714, GSC locality 29224.

Figures 2 - 14. *Strophodonta (Strophodonta) inflexa* (Swallow)

2 - 6 Pedicle (2 and 3), x1 and x2, lateral (4), posterior (5) and anterior (6) views of a young adult individual, x1, GSC 58706, GSC locality 46169.

7, 8 Pedicle (7), and lateral (8) views of a thick, elongate gerontic individual, x1, GSC 58707, GSC locality 45983.

9 - 14 Pedicle (9), x1, interior of pedicle valve (10 and 11), x1 and x2, lateral (12), posterior (13) and anterior (14) views of a relatively broad adult individual, x1, GSC 58708, GSC locality 45999.

Figures 15,17-18. *Strophodonta (Strophodonta) moberliensis* n. sp.

15 Brachial view of a young individual, x1, GSC paratype 58715, GSC locality 46029.

17 Pedicle view of a young individual partly embedded in matrix, x1, GSC holotype 58716, GSC locality 46029.

18 Pedicle view of a wide, mature adult individual, x1, GSC paratype 58717, GSC locality 46029.

Figures 16, 19 - 20. *Nervostrophia* sp.

16 View of interior of brachial valve of a young individual embedded in matrix, x2, GSC 58720, GSC locality 45999.

19 View of exterior of pedicle valve of an adult individual, x1, GSC 57818, GSC locality 46000.

20 View of interior of brachial valve of an adult individual embedded in matrix, x1, GSC 58719, GSC locality 29241.

Figures 21 - 32. *Eostrophalosia pedderi* Crickmay

21, 22 Pedicle (21), x1, and cardinal area and umbo of pedicle valve (22), x2, views of an adult individual embedded in matrix, GSC 58743, GSC locality 46113.

23, 24 Pedicle (23) and lateral (24) views of a small adult individual, x1, GSC 58744, GSC locality 46113.

25, 26 Pedicle (25) and lateral (26) views of a large adult individual embedded in matrix, x1, GSC 58545, GSC locality 29176.

27, 28 Views of brachial valve of an adult individual embedded in matrix, x1 and x2, GSC 58746, GSC locality 46275.

29, 30 Views of interior of brachial valve of a young adult individual embedded in matrix, x1 and x2, GSC 58747, GSC locality 46022.

31 View of interior of brachial valve of a mature adult individual embedded in matrix, x2, GSC 58748, GSC locality 46094.

32 View of interior of brachial valve of a mature adult individual embedded in matrix, x2, GSC 58749, GSC locality 46052.

Figures 33 - 35. *Devonoproductus catamorphus* (Crickmay)

33 Exterior view of pedicle valve of an adult individual showing spines along the cardinal margin, embedded in matrix, x4.9, GSC 58750, GSC locality 46043.

34 Exterior view of pedicle valve of an adult individual showing spines at the cardinal angles and near the anterior margin, embedded in matrix, x5, GSC 58751, GSC locality 46043.

35 Exterior view of pedicle valve of a small adult individual showing costae, concentric growth lines, and scattered spines mainly along the cardinal margin, embedded in matrix, x5, GSC 58752, GSC locality 46172.

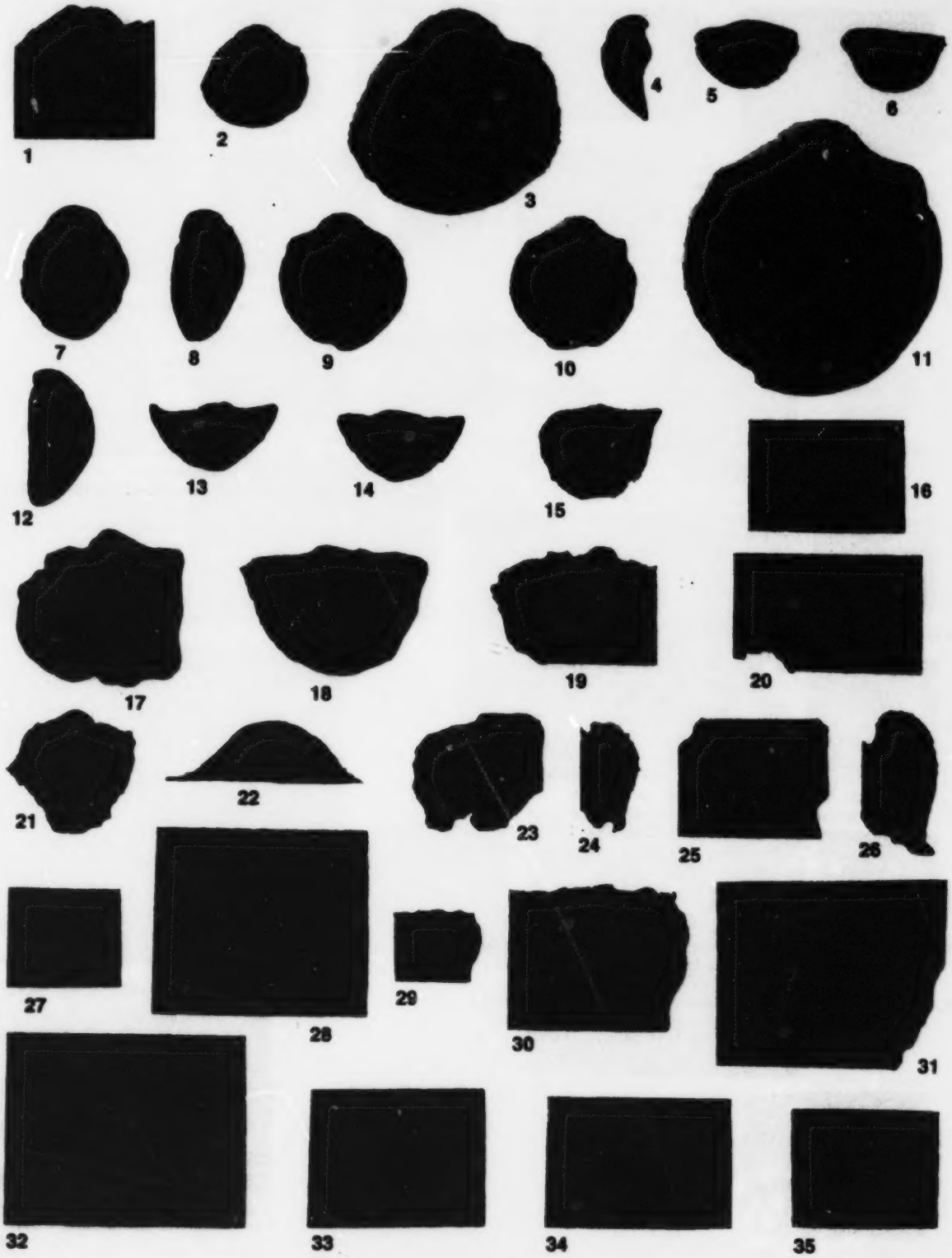
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PLATE 7

Figures 1 - 7. *Devonoproductus catamorphus* (Crickmay)

1 Exterior view of pedicle valve of a small adult individual showing spines along the cardinal margin and near anterior margin, embedded in matrix, x3, GSC 58753, GSC locality 46172.

2 Exterior view of a brachial valve of a medium size adult individual, embedded in matrix, x5, GSC 58754, GSC locality 46043.

3 Exterior view of a brachial valve of a small adult individual, embedded in matrix, x5, GSC 58755, GSC locality 46172.

4 Interior of pedicle valve of a large adult individual, embedded in matrix, x5, GSC 58756, GSC locality 46172.

5 Interior of a pedicle valve of a large adult individual, embedded in matrix, x5, GSC 58757, GSC locality 46043.

6 Interior of a brachial valve of an adult individual, embedded in matrix, x5, GSC 58758, GSC locality 46043.

7 Interior of a brachial valve of an adult individual, embedded in matrix, x5, GSC 58759, GSC locality 46043.

Figures 8 - 18. *Devonoproductus reticulocostus* n. sp.

8, 9 Exterior views of pedicle valve of a medium size adult individual, embedded in matrix, x1 and x2, GSC holotype 58760, GSC locality 46133.

10, 11 Exterior views of brachial valve of a medium size adult individual, embedded in matrix, x1 and x2, GSC paratype 58761, GSC locality 46133.

12 Exterior view of pedicle valve of a medium size adult individual embedded in matrix, x2, GSC paratype 58762, GSC locality 46133.

13 Exterior view of pedicle valve of a large adult individual, embedded in matrix, x1, GSC paratype 58763, GSC locality 46133.

14 Exterior view of brachial valve of a small adult individual, embedded in matrix, x2, GSC paratype 58764, GSC locality 46133.

15, 16 Exterior views of pedicle valve of a large elongate adult individual, x1 and x2, GSC paratype 58765, GSC locality 45976.

17, 18 Interior views of brachial valve of a large adult individual, embedded in matrix, x1 and x2, GSC paratype 58766, GSC locality 29089.

Figures 19 - 30. *Devonoproductus tertius* Crickmay

19 Exterior view of pedicle valve of a medium size individual, embedded in matrix, x5, GSC 58767, GSC locality 46102.

20 Exterior view of pedicle valve of a medium size individual, embedded in matrix, x5, GSC 58768, GSC locality 46156.

21 Exterior view of brachial valve of a young individual, embedded in matrix, x5, GSC 58769, GSC locality 46102.

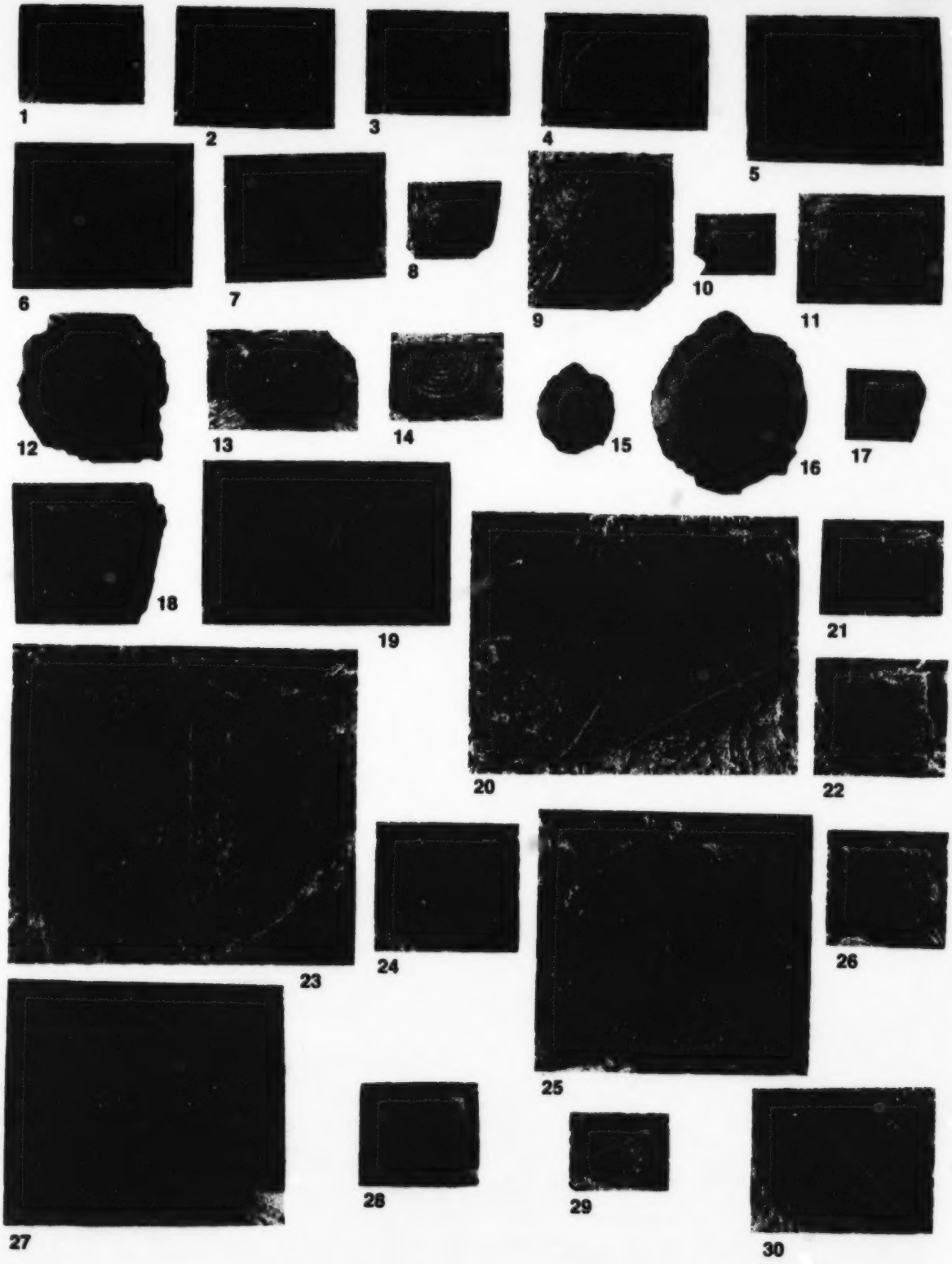
22 Interior view of brachial valve of a young individual, embedded in matrix, x5, GSC 58770, GSC locality 46102.

23, 24 Interior views of brachial valve of a mature adult individual, embedded in matrix, x5 and x2, GSC 58771, GSC locality 46078.

25, 26 Interior views of brachial valve of a mature adult individual, embedded in matrix, x5 and x2, GSC 58772, GSC locality 46078.

27, 28 Interior views of brachial valve of a mature adult individual, embedded in matrix, x5 and x2, GSC 58773, GSC locality 46078.

29, 30 Interior views of brachial valve of a mature adult individual, embedded in matrix, x1 and x2, GSC 58774, GSC locality 46078.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GEOLOGICAL SURVEY OF CANADA COMMISSION GÉOLOGIQUE DU C

DEPARTMENT OF ENERGY, MINES AND RESOURCES
MINISTÈRE DE L'ÉNERGIE, DES MINES ET DES RESSOURCES

LEGEND

MESOZOIC

CRETACEOUS

K1 — *Undivided*

DEVONIAN

UPPER DEVONIAN

D9 — *WATERWAYS FORMATION: Mildred Member; argillaceous limestone and shale; not exposed*

D8 — *Moberly Member: fragmental limestone, limestone, argillaceous limestone, and shale*

D7 — *Christina Member: argillaceous limestone, limestone, shale and some sandstone*

D6 — *Calumet (Calmut) Member: limestone, argillaceous limestone and shale*

D5 — *Firebag Member: shale and argillaceous limestone*

PALEOZOIC

D4 — *SLAVE POINT FORMATION: dolomitic limestone and limestone; minor gypsum; strongly brecciated in places; exposed north of map area*

MIDDLE DEVONIAN

D3a — *PRAIRIE EVAPORITE FORMATION: gypsum, anhydrite and salt, and siltstone and shale; not exposed because of removal by solution at and near surface, present in the deeper subsurface*

D3 — *METHY FORMATION: dolomite, in part reefal, calcareous dolomite; minor gypsiferous dolomite, in part brecciated; basal beds sandy conglomeratic where formation overlaps the Canadian Shield*

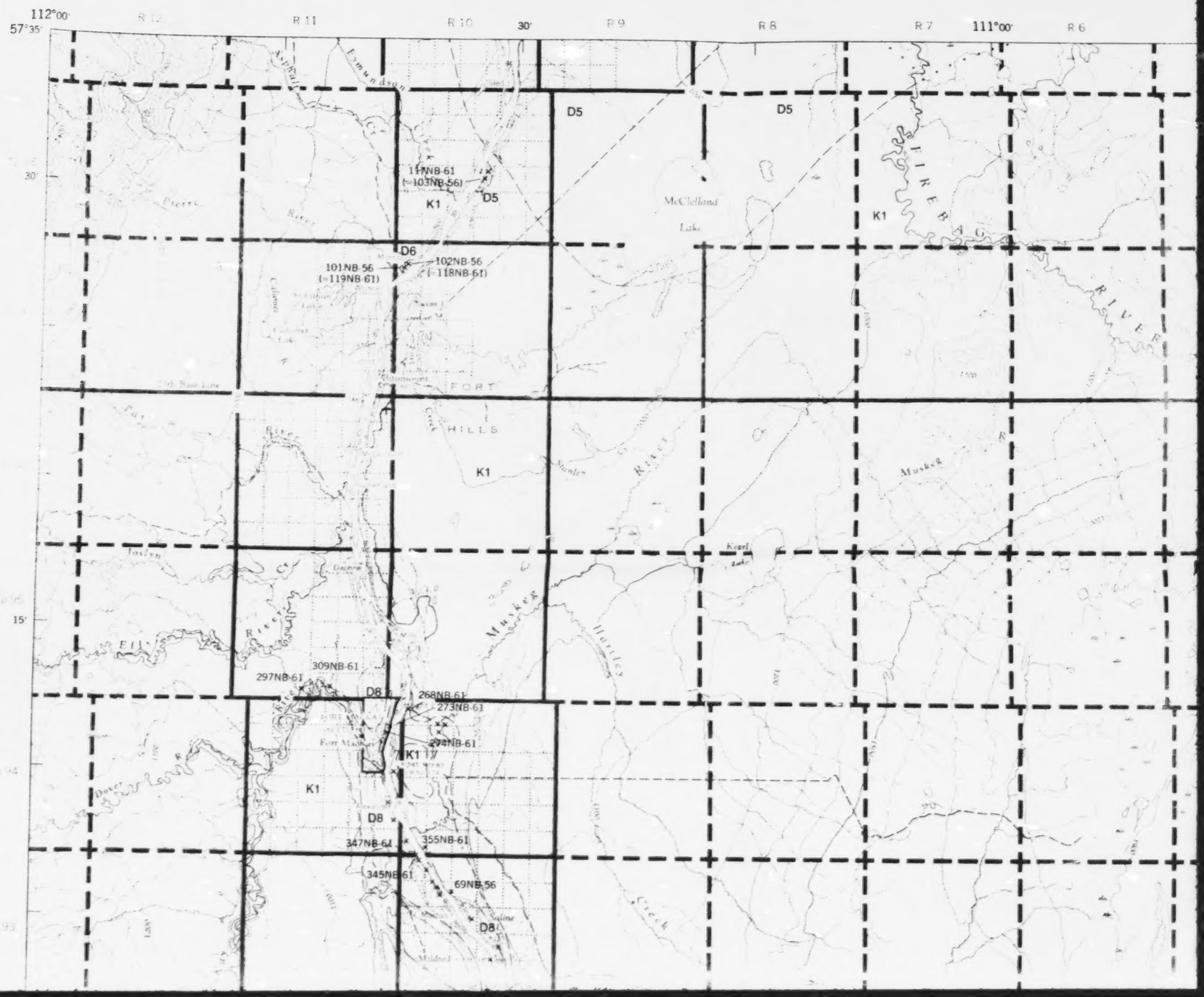
D2 — *McLEAN RIVER FORMATION: shale, sandy and silty shale, dolomite, sandy and calcareous dolomite*

MIDDLE DEVONIAN AND/OR OLDER

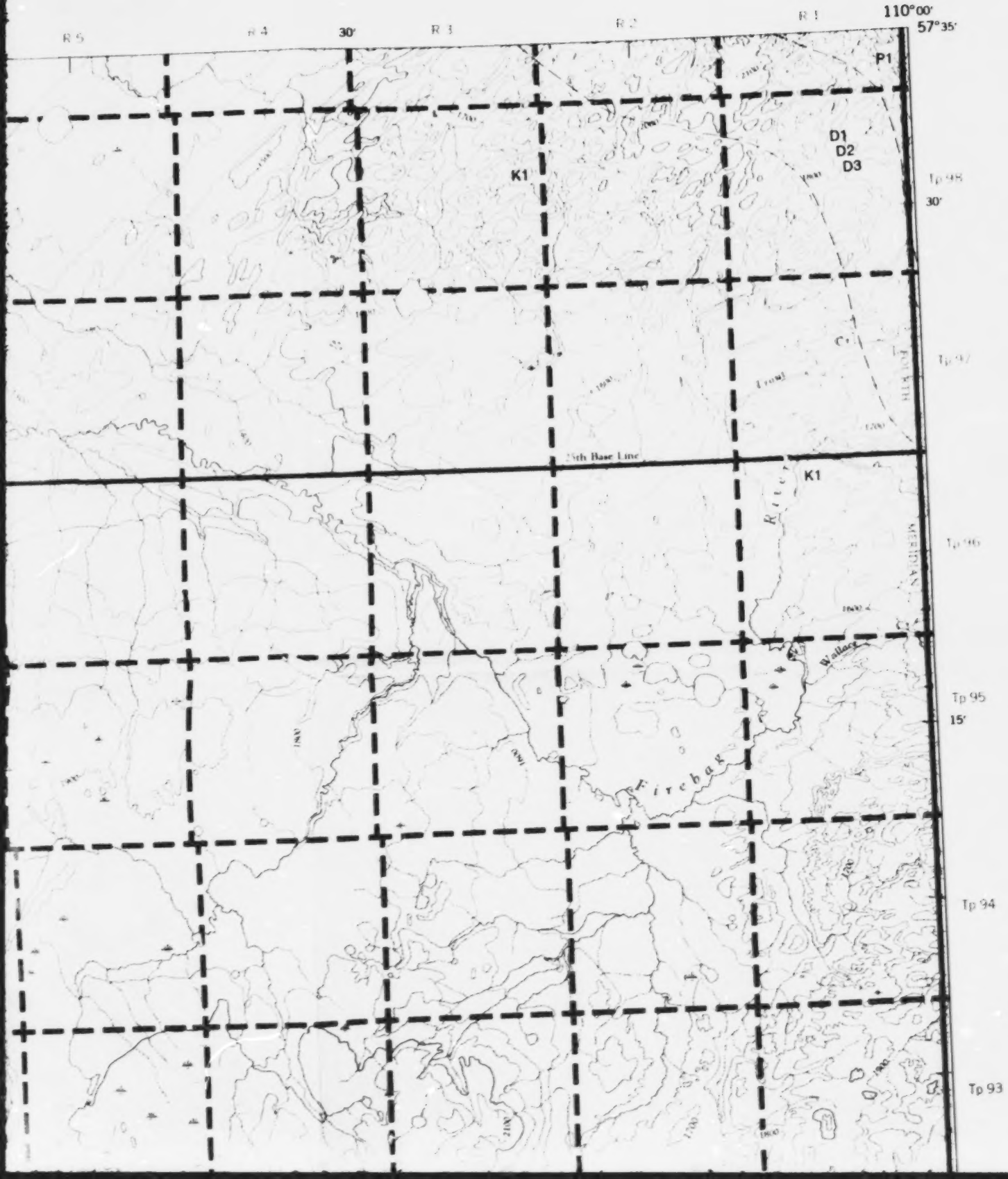
D1 — *LA LOCHE FORMATION: arkosic sandstone and conglomeratic sandstone*

PRECAMBRIAN

P1 — *Undivided*



U CANADA


110°00'
57°35'
R 5
R 4
30'
R 3
R 2
R 1
P1
D1
D2
D3
K1
Tp 98
30'
Tp 97
5th Base Line
K1
Tp 96
Wallace
Tp 95
15'
Firebag
Tp 94
Tp 93

Metres Feet

680
200
640
600
175
560
520
150
480
440
125
400
360
100
320

Mildred Member 42 ± m (140± ft) (not exposed)

Moberly Member 60 ± m (200± ft)

Grand Rapids Member 27 ± m (90± ft)

FORMATION

WATERWAYS

6.1 km 3.8 miles | 0.3 km 0.2 mile | 22.9 km 14.2 miles | 1.4 km 0.9 mile | 4.3 km 2.7 miles | 1.3 km 0.8 mile | 0.3 km 0.2 mile | 6.3 km 3.9 miles

Athasbasca River | *MacKay River* | *Athasbasca River*

297NB-61

297NBa

RL

309NB-61

309NBa 309NBb 309NBc

RL

268NB-61

268NBd 268NBc 268NBb 268NBa

RL

273NB-61

273NBb 273NBa

RL

274NB-61

274NBe 274NBd 274NBc 274NBa 274NBg

RL

GEOLOGICAL SURVEY OF CANADA COMMISSION GÉOLOGIQUE DU CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES
MINISTÈRE DE L'ÉNERGIE, DES MINES ET DES RESSOURCES

0.6 km 0.4 mile | 0.2 km 0.1 mile | 2.9 km 1.8 miles | 39.6 km 24.6 miles | 20.1 km 12.5 miles | 10.9 km 6.8 miles | 4.3 km 2.7 miles | 0.6 km 0.4 mile | 3.2 km 2.0 miles

Beaver River

Clearwater River

5NB-61

—355NBg
—355NBf
—355NBe
—355NBd
—355NBc
—355NBb
—355NBa

345NB-61

—345NBd
—345NBc
—345NBb
—345NBe
—345NBa
—345NBf

RL

347NB-61

—347NBa
—347NBc
—347NBb

RL

69NB-56

—246NBa
—245NBc
—245NBb
—245NBa
—244NBb

RL

56NB-61

—56NBa

RL

35NB-61

—35NBa

RL

3.2 km
2.0 miles
0.24 km
0.15 mile
0.56 km
0.35 mile
16.1 km
10.0 miles
High Hill River

PALEOZOIC

D6 — *Calumet (Caimut) Member: limestone, argillaceous limestone and shale*

D5 — *Firebag Member: shale and argillaceous limestone*

D4 — *SLAVE POINT FORMATION: dolomitic limestone and limestone; minor gypsum; strongly brecciated in places; exposed north of map area*

MIDDLE DEVONIAN

D3a — *PRAIRIE EVAPORITE FORMATION: gypsum, anhydrite and salt, and siltstone and shale; not exposed because of removal by solution at and near surface, present in the deeper subsurface*

D3 — *METHY FORMATION: dolomite, in part reefal, calcareous dolomite; minor gypsiferous dolomite, in part brecciated; basal beds sandy conglomeratic where formation overlaps the Canadian Shield*

D2 — *McLEAN RIVER FORMATION: shale, sandy and silty shale, dolomite, sandy and calcareous dolomite*

MIDDLE DEVONIAN AND/OR OLDER

D1 — *LA LOCHE FORMATION: arkosic sandstone and conglomeratic sandstone*

PRECAMBRIAN

P1 — *Undivided*

Rock outcrop, area of outcrop
Geological boundary (approximate and assumed)
Limits of geology
Station localities (referred to in text) ..... 9NB-61 to 162NB-56

Compilation by A.W. Norris

To accompany GSC Bulletin 350 by A.W. Norris

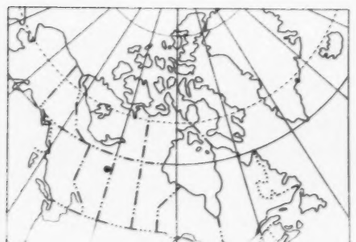
Main sources of data:

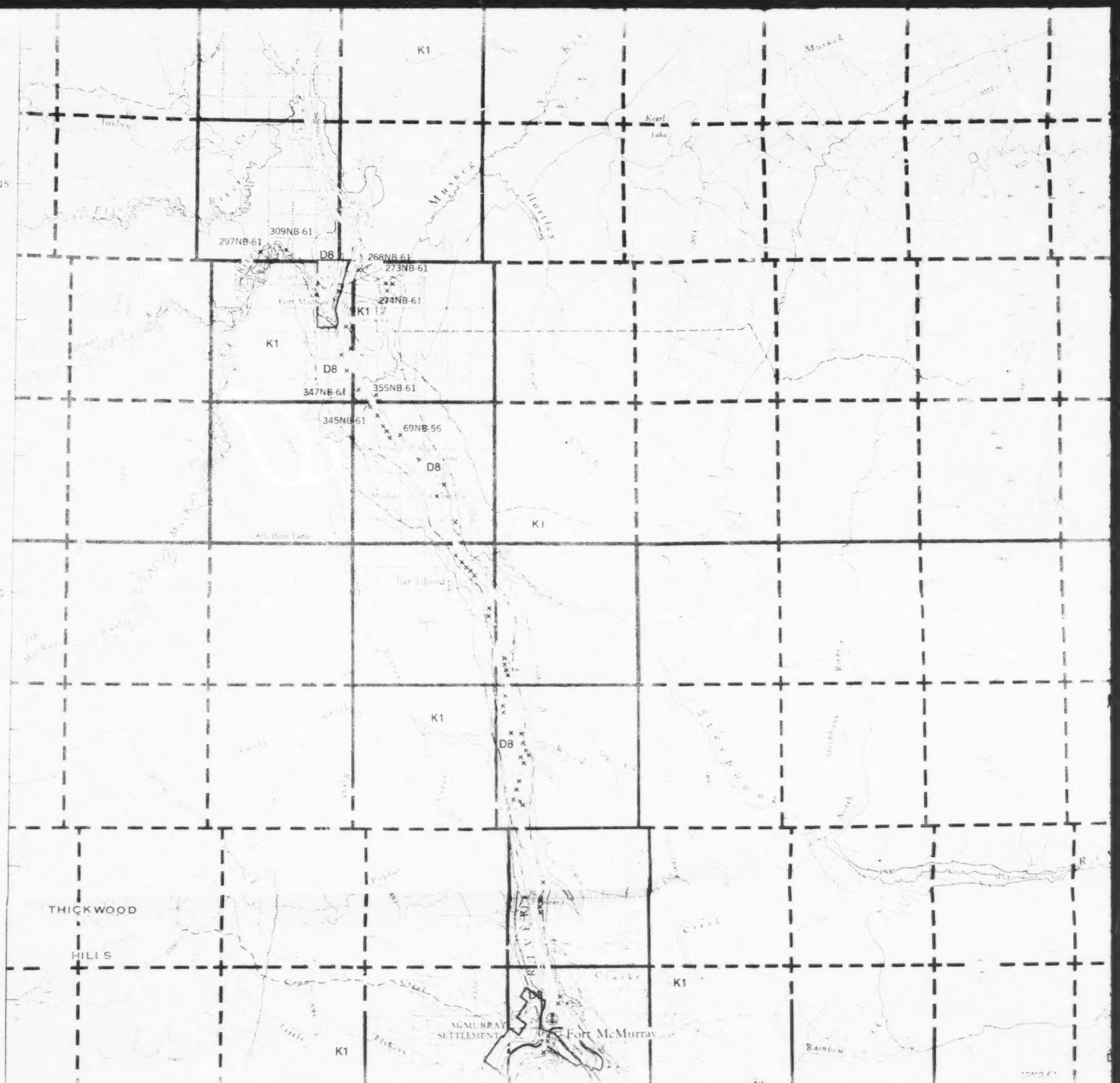
Carrigy, M.A., 1959; Green, R., 1972; Green, R., Mellon, G.B., and Carrigy, M.A., 1970; Hamilton, W.N., 1969; Norris, A.W., 1953, 1973; Tremblay, L.P., 1961a, b.

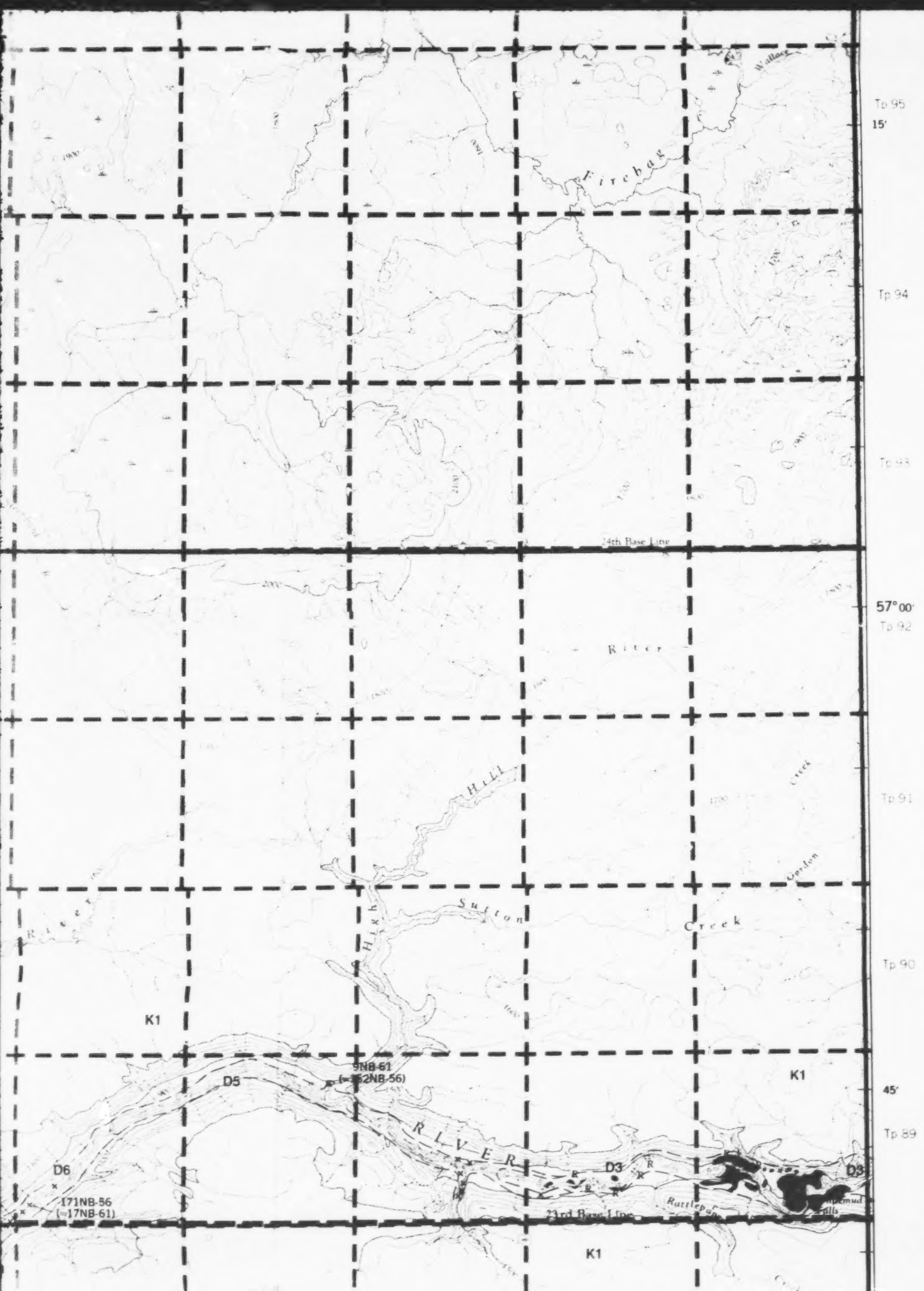
Geological cartography by J.H. Waddell, Institute of Sedimentary and Petroleum Geology, Geological Survey of Canada

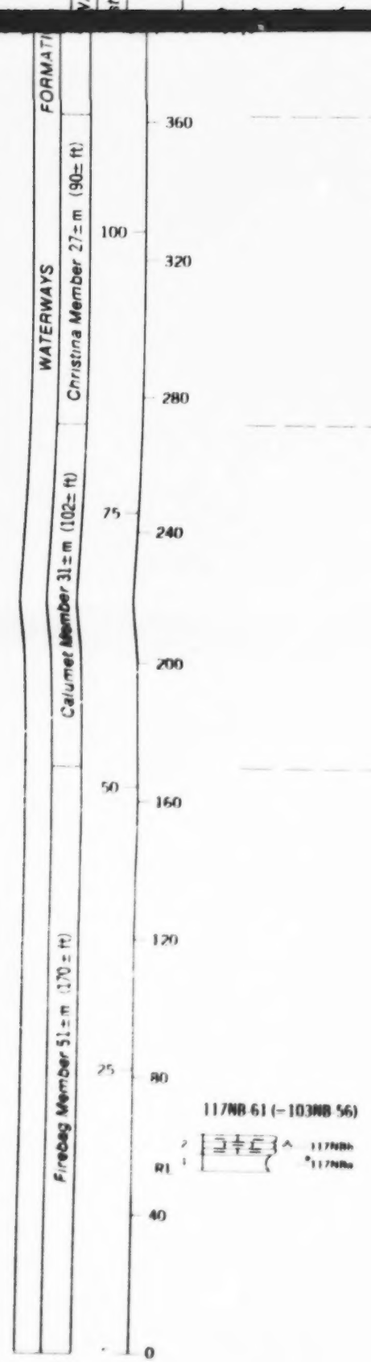
Base-map from parts of 1/250,000 scale maps 74E and 74D published by Surveys and Mapping Branch in 1958, 1960

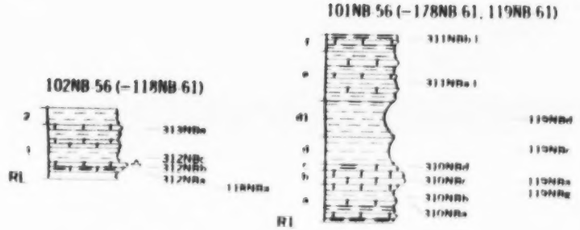
Elevations in feet above mean sea-level

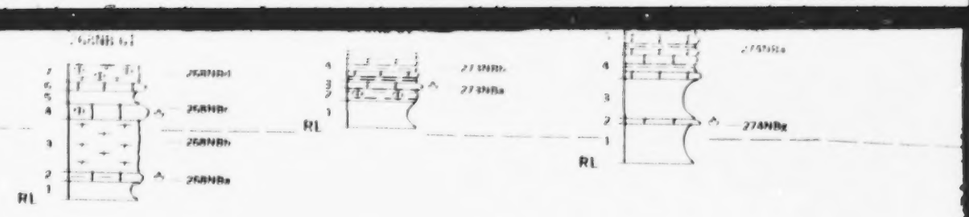




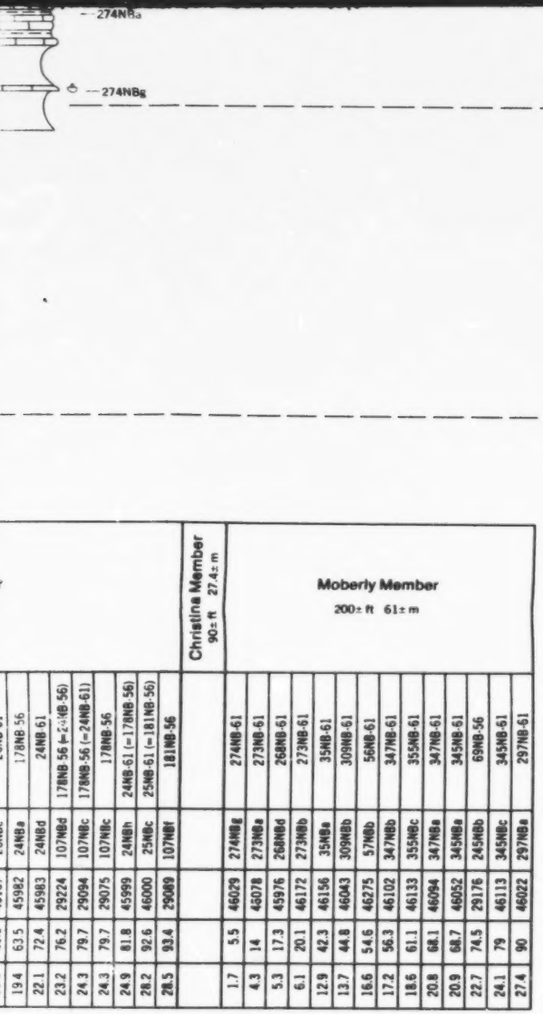

Tp 95
15'
Firebag
Tp 94
Tp 93
24th Base Line
57°00'
Tp 92
River
Tp 91
Creek
Gordon
Sutton
Creek
Tp 90
K1
K1
D5
9NB-61
(=152NB-56)
RIVER
D6
171NB-56
(=17NB-61)
D3
D3
45'
Tp 89
23rd Base Line
K1



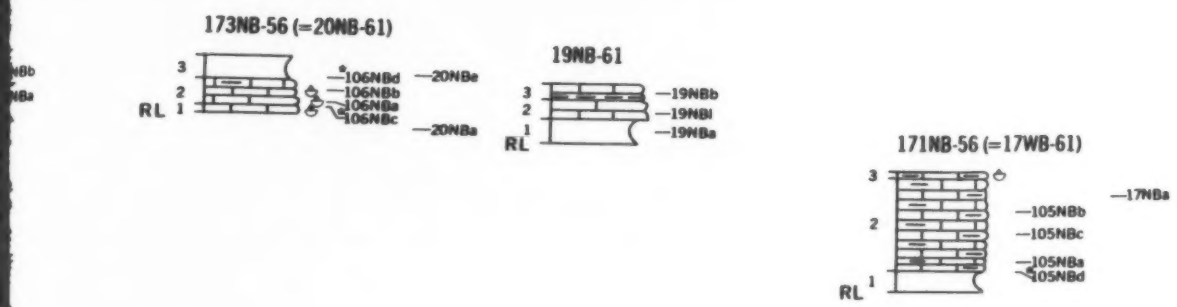


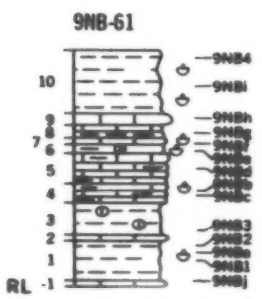


| Station Number | | Fireb. Member | Calumet Member | | |


Christina Member
90± ft 27.4± m
Moberly Member
200± ft 61± m
274NBa
274NBg
RL

| | | |





Printed by the Surveys and Mapping Branch. Published, 1982

Figure 2
Bulletin 350

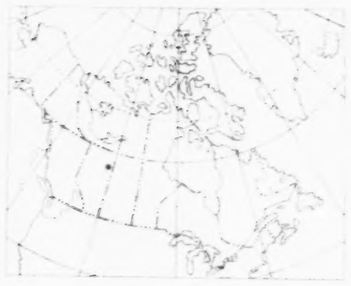
To accompany GSC Bulletin 350 by A.W. Norris

Main sources of data:
Carrigy, M.A., 1959; Green, R., 1972; Green, R., Mellon, G.B., and Carrigy, M.A., 1970; Hamilton, W.N., 1969; Norris, A.W., 1953, 1973; Tremblay, L.P., 1961a, b.

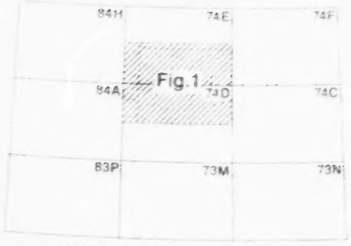
Geological Lithography By J.H. Wadden, Institute of Sedimentary and Petroleum Geology, Geological Survey of Canada

Base-map from parts of 1:250,000 scale maps 74E and 74D published by Surveys and Mapping Branch in 1958, 1960

Elevations in feet above mean sea-level



INDEX MAP



NATIONAL TOPOGRAPHIC SYSTEM REFERENCE

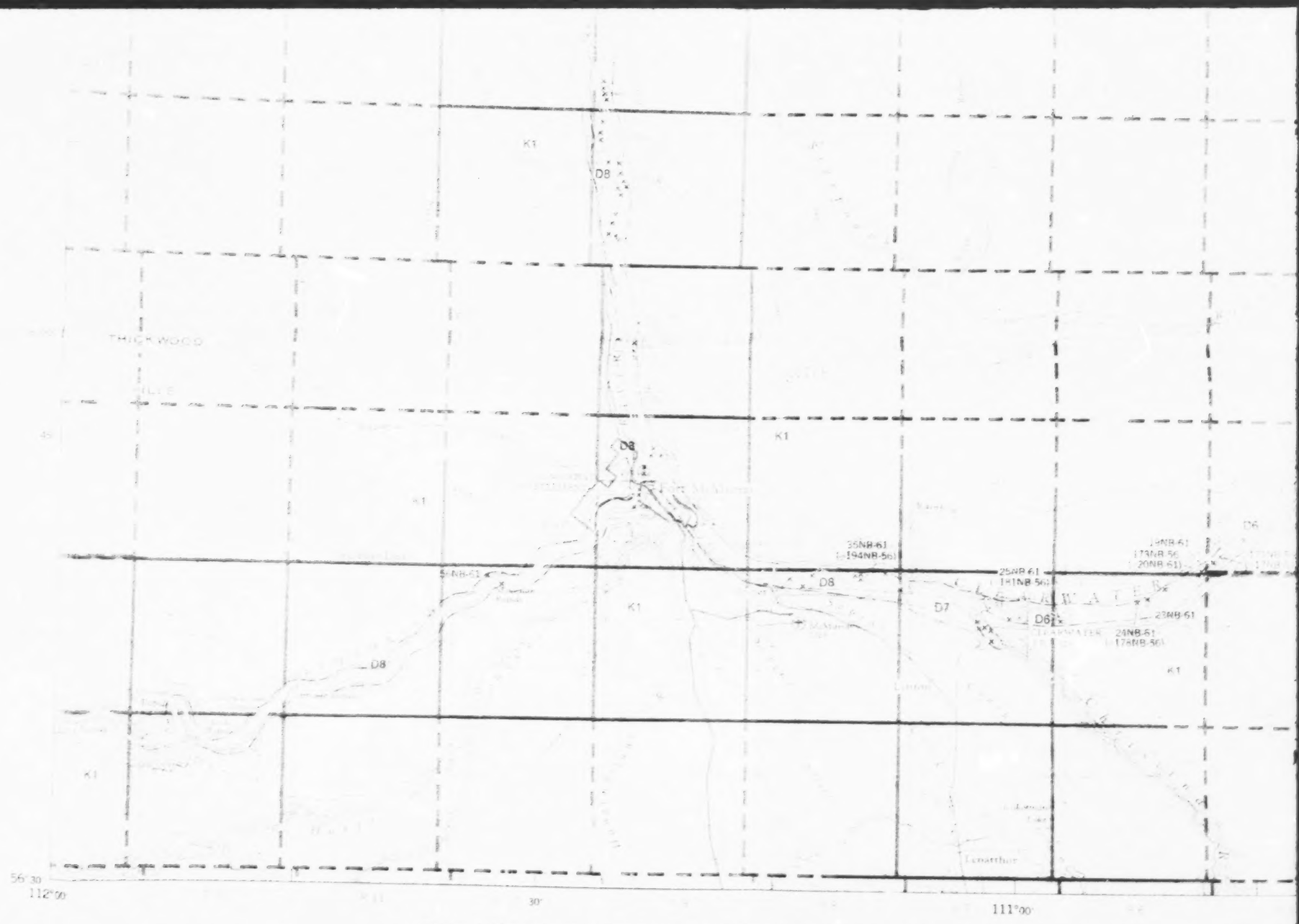


Figure 1. Map showing distribution of the Waterways Formation along the Clearwater and Athabasca Rivers, and

Scale 1:250,000

Kilometres 6 0 6 12 18 Kilometres

Miles 4 0 4 8 Miles

Transverse Mercator Projection

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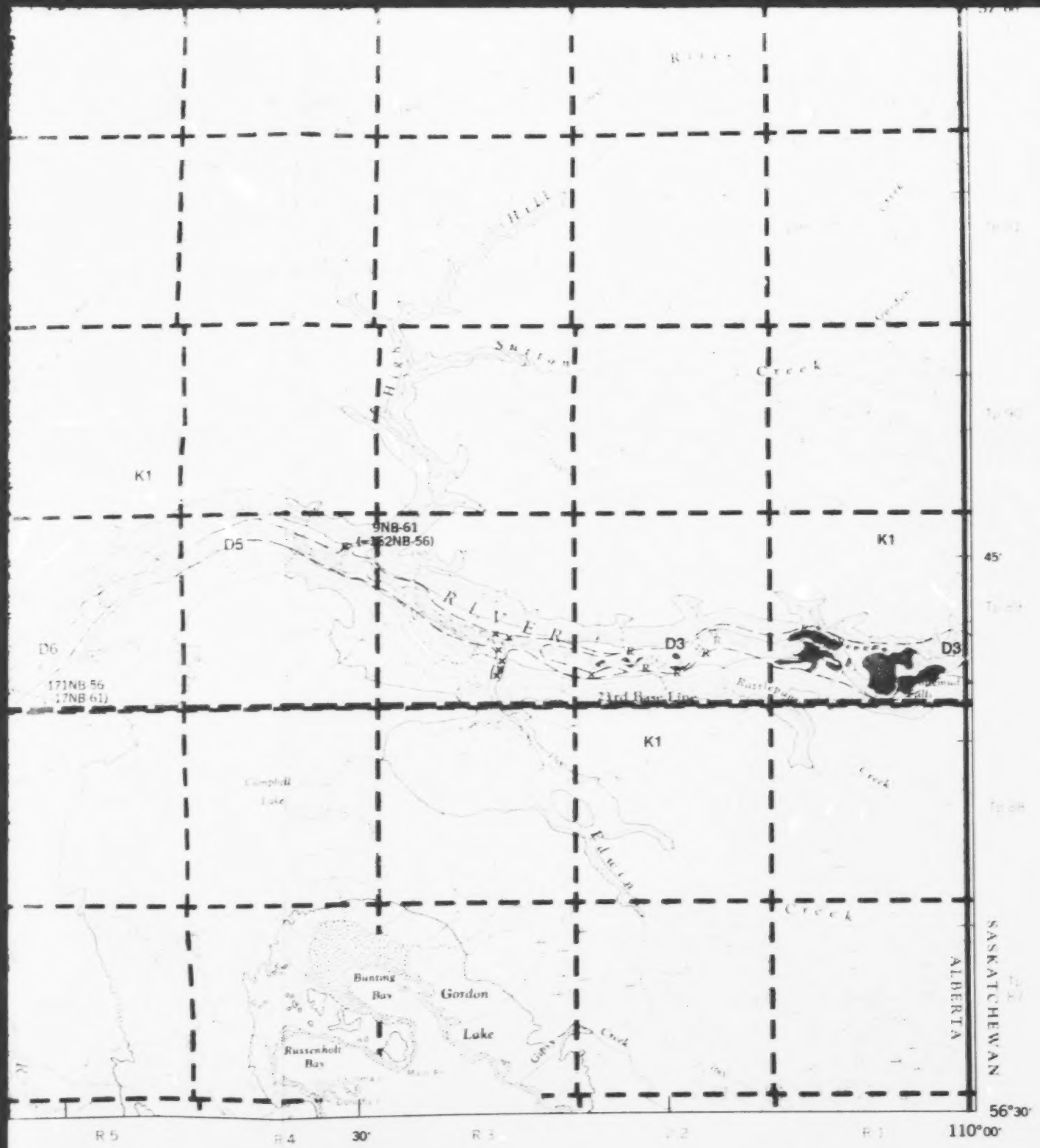
Canada



Rivers, and station localities of figured specimens.

Kilometres

Figure 1.

Bulletin 350

POOR

QUALITY

ORIGINAL